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VIBRATION-RESPONSE TESTS OF A $\frac{1}{5}$-SCALE MODEL OF THE GRUMMAN F6F AIRPLANE IN THE LANGLEY 16-FOOT HIGH-SPEED TUNNEL

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NACA

WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

VIBRATION-RESPONSE TESTS OF A $\frac{1}{5}$-SCALE MODEL OF THE GRUMMAN F6F AIRPLANE IN THE LANGLEY 16-FOOT HIGH-SPEED TUNNEL

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SUMMARY

A series of vibration experiments was conducted in the Langley 16-foot high-speed tunnel on a $\frac{1}{5}$-scale model of the Grumman F6F airplane. These tests were conducted to study the vibration responses of the model at airspeeds within the range of the tunnel, or up to approximately 500 miles per hour. Within this range, there was no indication of actual flutter either by shift of frequencies or by decreasing damping. The response curves are given in a series of graphs.

INTRODUCTION

A series of vibration tests of a $\frac{1}{5}$-scale model of the Grumman F6F airplane was performed in the Langley 16-foot high-speed tunnel. The purpose of the tests was to determine whether the model would stand speeds up to 500 miles per hour. Strain-gage recordings were made of forced vibration responses at 0, 250, and 400 miles per hour for purposes of determining the air damping.

MODEL AND TESTS

The model used in the tests was constructed of wood and magnesium by personnel of the Massachusetts Institute of Technology, who also participated in the tests. The model was designed to be a true $\frac{1}{5}$-scale model of the Grumman F6F airplane in regard to the major flutter parameters and thus was designed to have the same flutter speed as the actual airplane. Photographs of the model taken before the tests are shown in figure 1. A photograph of the recording equipment and some of the controls is given as figure 2.

The model was provided with an adjustable eccentric vibrator in each wing. These vibrators were driven by air turbines and could be run in phase or out of phase. The location of the vibrators is shown in figure 3.

The strain gages used in the tests were mounted both on the top and bottom of the spars in each of the positions shown in figure 3. The gages were connected electrically as indicated in figure 4. By appropriate combinations of the top and bottom gages on the front and rear spars the main torsion, bending, and chordwise responses could be obtained. Since the bending measurements were obtained only by gages on the front spars, considerable torsion response is evident in the records and the torsion response peaks are almost as prominent as the bending response peaks. Because the spars were of different dimensions, there was also some bending response in the torsion records.

The gages are identified by numbers and letters in figure 3 and on the oscillograph records. The first symbol indicates the type of gage hookup; thus, B is for bending, T for torsion, C for chordwise bending, A for aileron position indicator, and Tach for vibrator tachometers. The second symbol, R or L, indicates right or left wing. The two numbers designate the position of the gages in percent of semispan as measured from the center line of the fuselage. Thus, BL21 means bending gage on left wing at 21 percent of the semispan.

A sample of the records taken during the tests is given for 0, 250, and 400 miles per hour in figures 5 to 7. A record taken at about the time of failure is shown in figure 8. The responses in this case are not forced by the vibrator but are entirely dependent on the air stream. The number preceding the gage designation in these figures represents the attenuation of the amplifiers.

Plots of the strain-gage responses for symmetrical forced vibrations are given for the various gages in figure 9. The responses for unsymmetrical excitation are given in figure 10. Data are presented for 0, 250, and 400 miles per hour, but curves are drawn only through the points for zero airspeed since the data at higher airspeeds in most cases are not sufficiently consistent.

The mode of vibration at the various response peaks is indicated in figures 11 to 15. The mode of vibration at about the time of failure is given in figure 16. The relative sizes of the plus and minus signs in these figures indicate the order of magnitude of the strain. The signs for the bending gages are placed between the spars, and the torsion responses are indicated by the signs in the circles. The following convention has been adopted for the bending- and torsion-gage signs: A plus sign on the front spar indicates torsion in a downward direction at the leading edge and a plus sign on the bending gage indicates deflection of the wing in a downward direction.

RESULTS

The natural frequencies of the model as measured at the Massachusetts Institute of Technology are given in table I. The first symmetrical bending and first unsymmetrical bending frequencies given in the table agree well with the results given herein. There is a small torsion peak in the unsymmetrical mode at about 122 cycles per second. A symmetrical second bending occurs at 130 cycles per second with a very wide response peak. The torsion response in this mode is very small. The conclusion is, therefore, that the response at 130 cycles per second is predominantly a second bending. The present test results seem to indicate that the unsymmetrical torsion response is lower than that given in table I and that probably both the symmetrical and the unsymmetrical torsion responses are at 120 cycles per second with the second symmetrical bending response at 130 cycles per second.

The records taken at 250 and 400 miles per hour show that the first symmetrical response cannot be found and that the first unsymmetrical response is reduced to about one-fifth of the response at zero airspeed. It was also found that the extraneous responses increased greatly with tunnel speed. It appears that good vibration-response records at high airspeeds can be obtained only by the use of a much larger vibrator force. Maximum recorded stresses amounted to only a few hundred pounds per square inch.

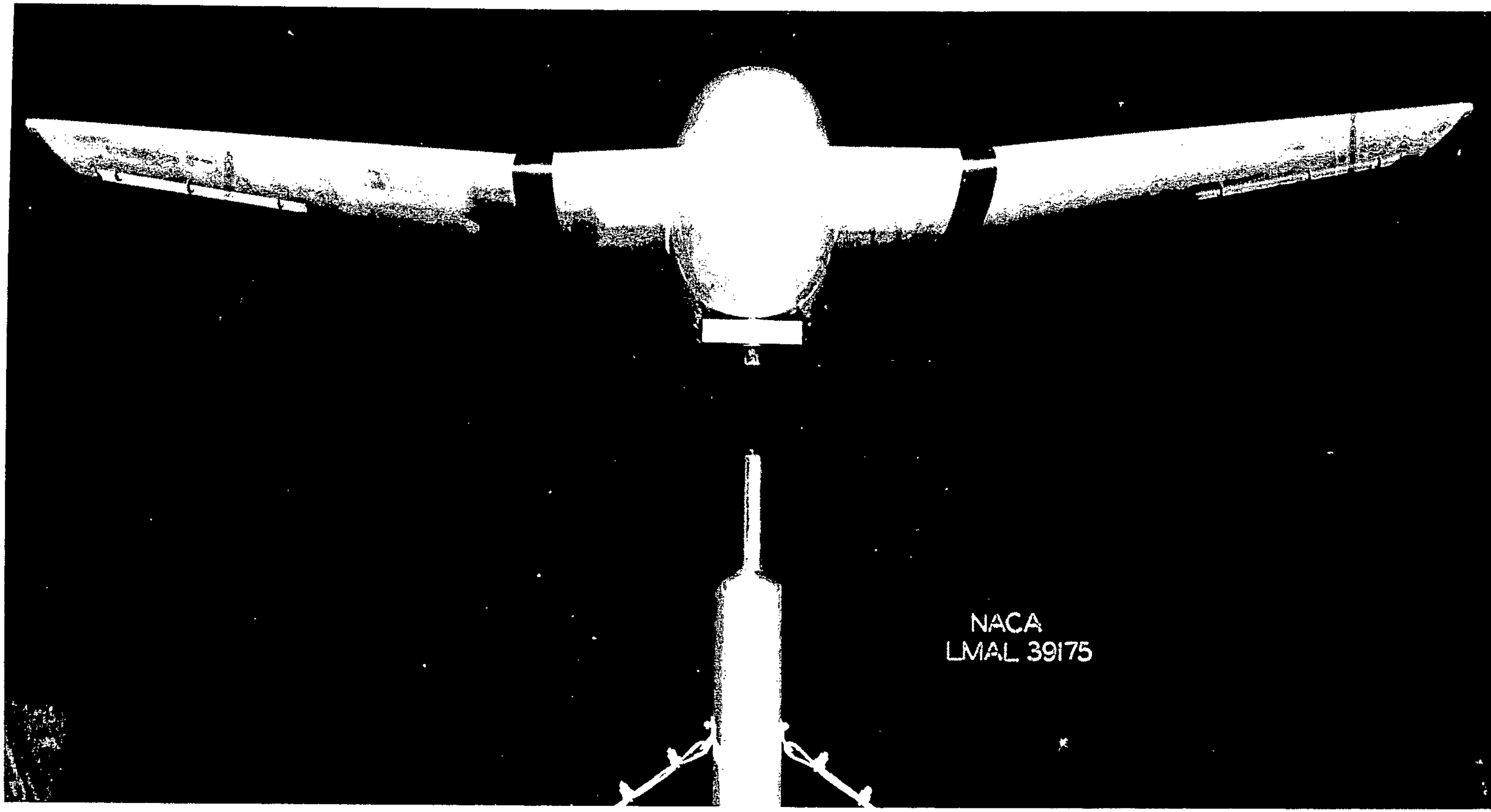
At 500 miles per hour a large response occurred at about 50 cycles per second, which blanketed any response from the vibrators. The tests were stopped because of failure of the soldered joints in the aileron supports. Photographs of the model taken after the failure are shown in figure 17.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., November 18, 1944

TABLE I

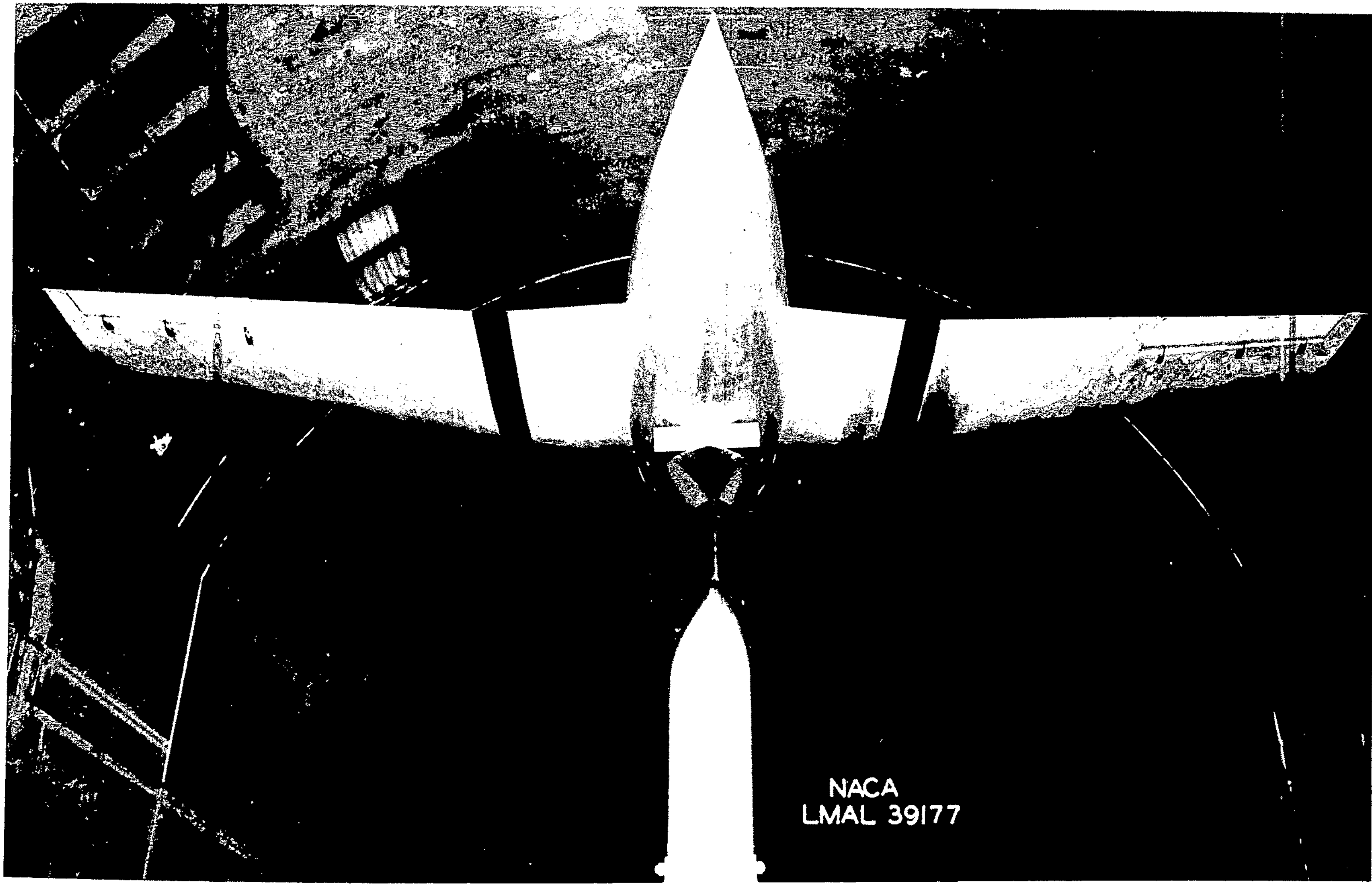
NATURAL FREQUENCIES OF THE MODEL AS MEASURED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Designation of mode	Frequency (cps)
Symmetrical	
First bending	48
Low torsion	120
Second bending	130
High torsion	158
Higher mode	220
Unsymmetrical	
First bending	90
Torsion	129



(a) Front view.

Figure 1.- The $\frac{1}{5}$-scale model of the Grumman F6F airplane mounted in the Langley 16-foot high-speed tunnel for vibration-response tests.



(b) Rear view.

Figure 1.- Concluded.

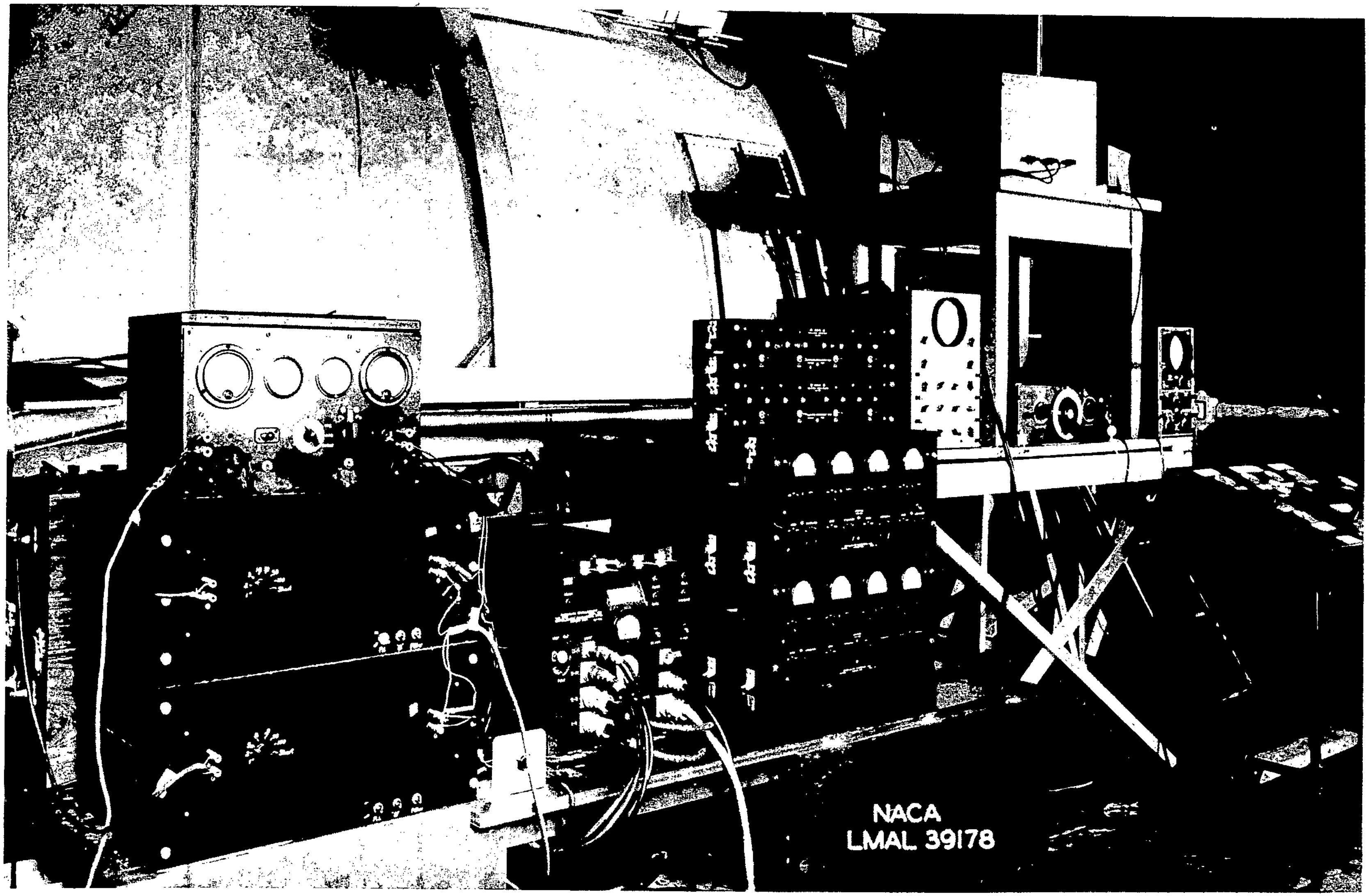


Figure 2.- Recording and control equipment used in tests.

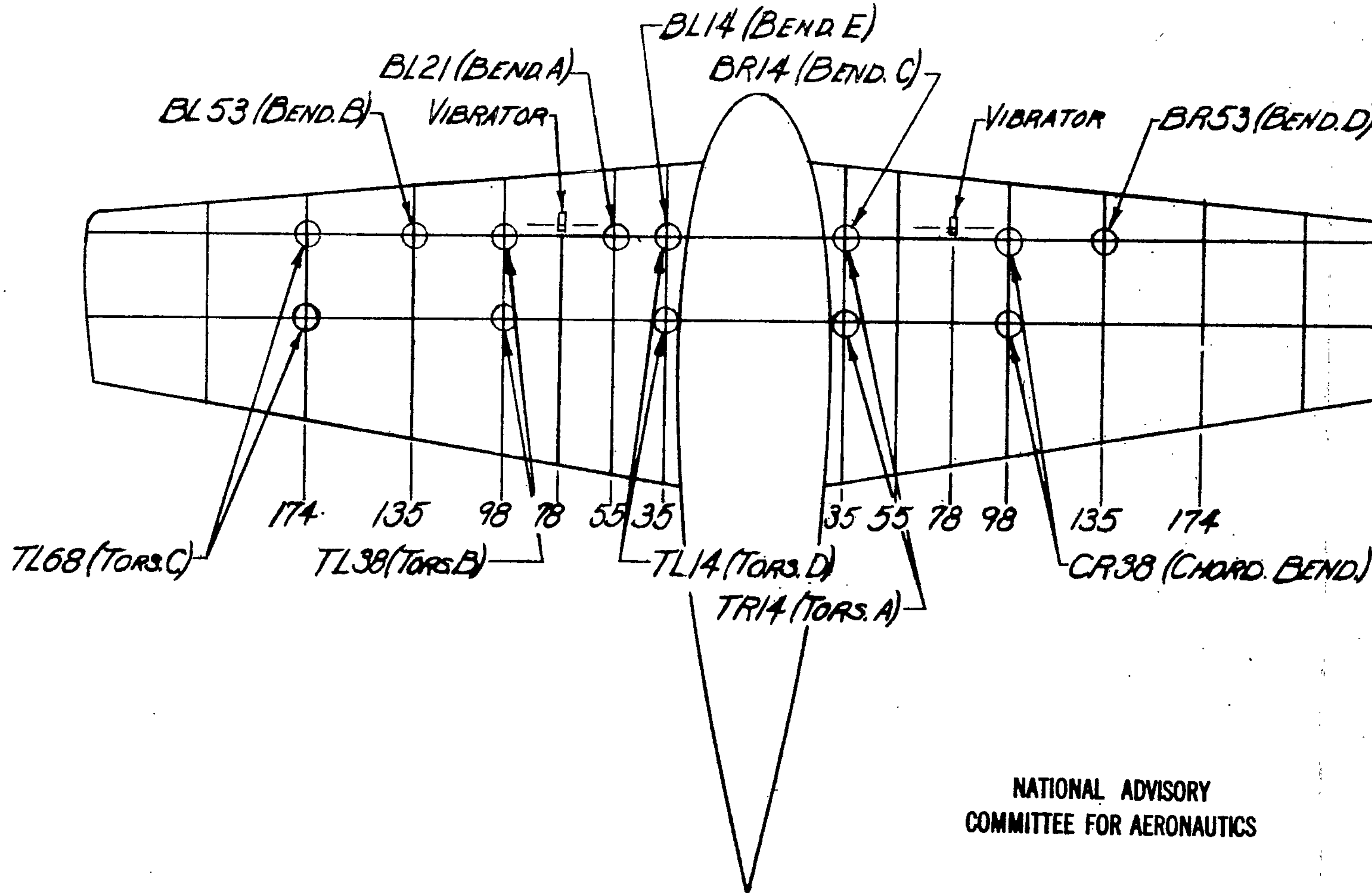


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Figure 3.- Location of vibrators and strain gages on model for tests at 250, 400, and 500 miles per hour in the Langley 16-foot high-speed tunnel. Scale shown below wing gives distance on actual airplane in inches from center line.

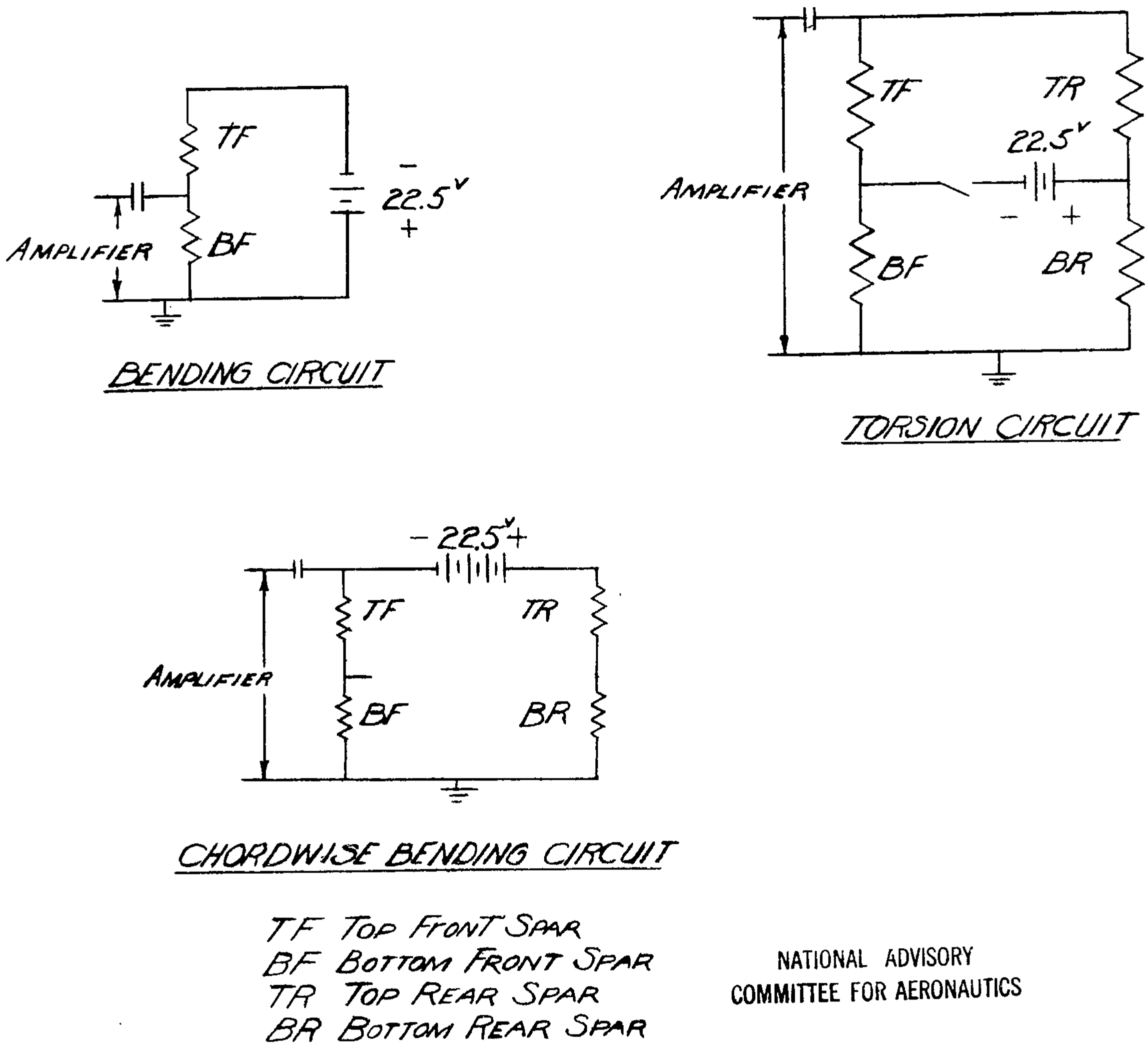

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Figure 4.- Strain-gage circuits for model. Strain gages are Baldwin-Southwark type C, 500 ohms.

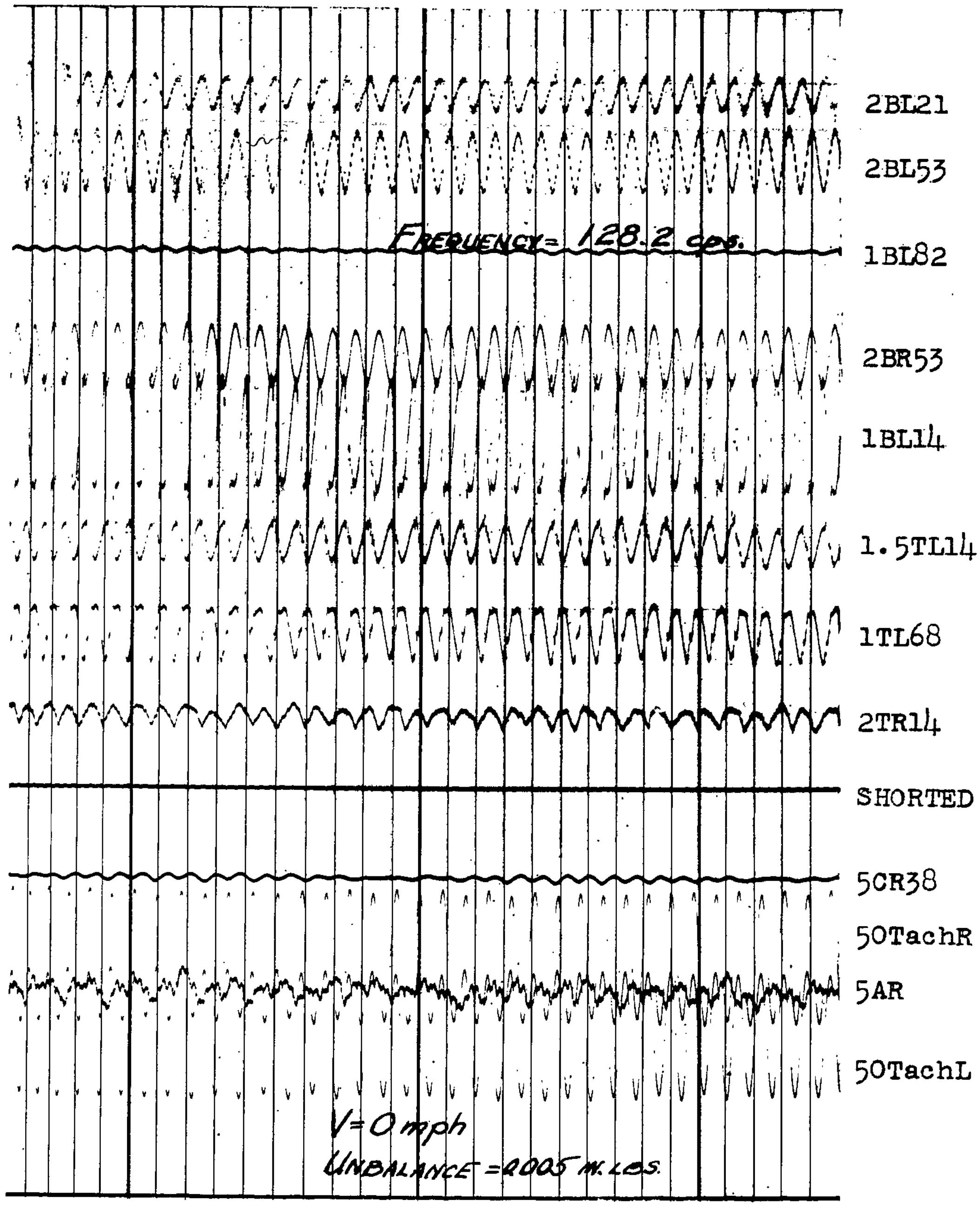

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Figure 5.- Oscillograph record taken at 0 miles per hour. Unbalance, 0.005 inch-pound; frequency, 128.2 cycles per second. (Symbols indicate attenuation and gage designation.)

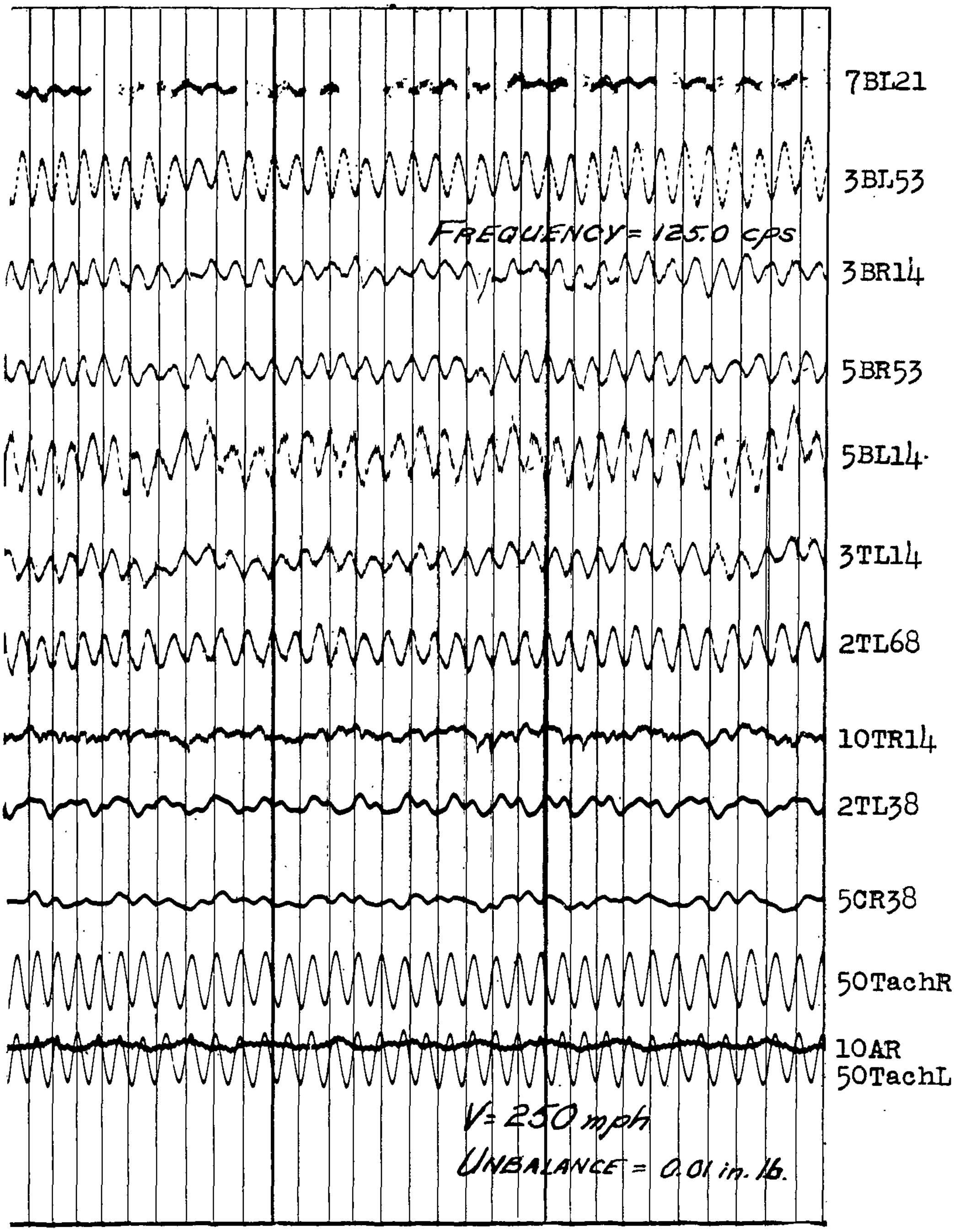

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Figure 6.- Oscillograph record taken at 250 miles per hour. Unbalance, 0.01 inch-pound; frequency, 125.0 cycles per second. (Symbols indicate attenuation and gage designation.)

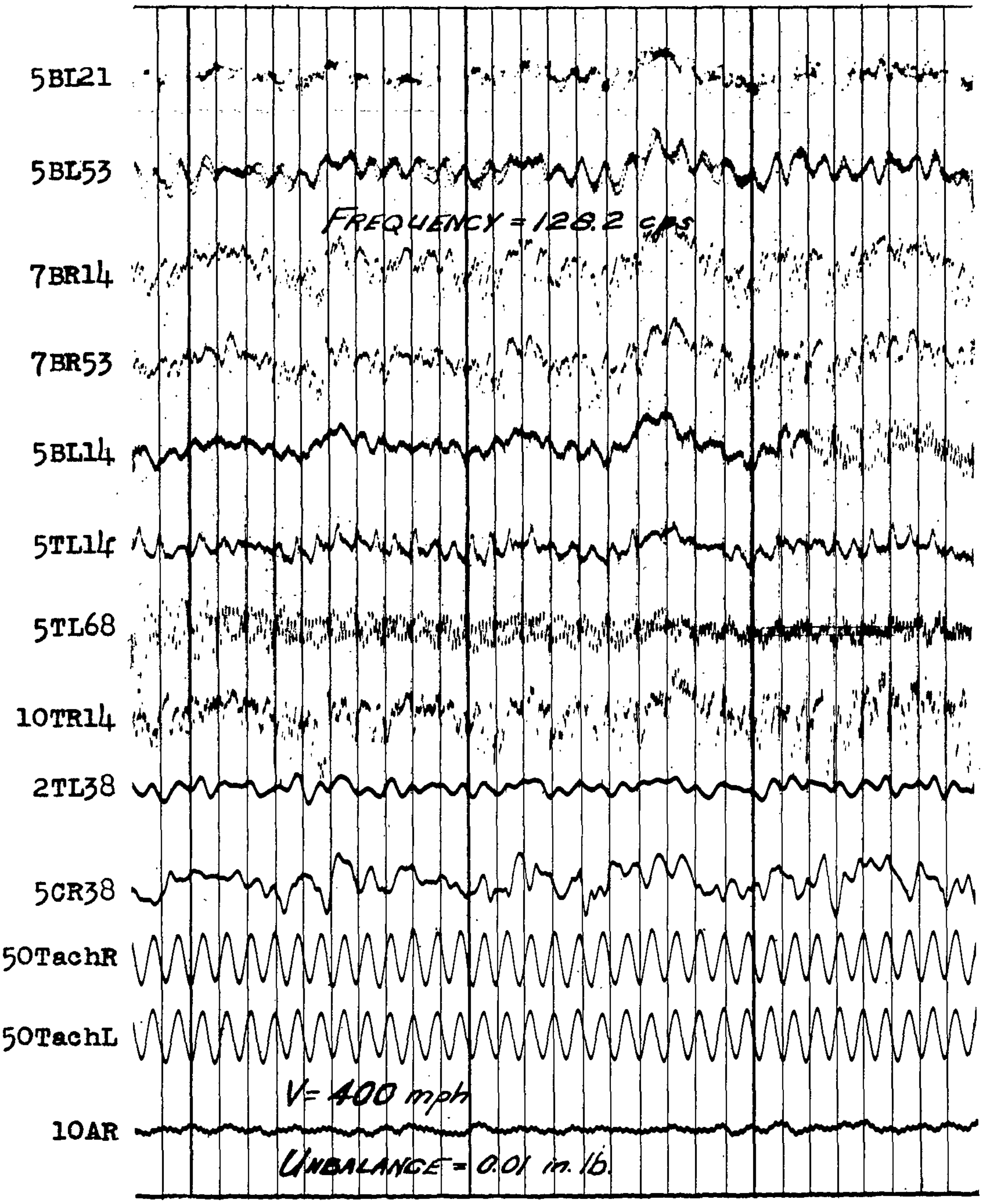

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Figure 7.- Oscillograph record taken at 400 miles per hour. Unbalance, 0.01 inch-pound; frequency, 128.2 cycles per second. (Symbols indicate attenuation and gage designation.)

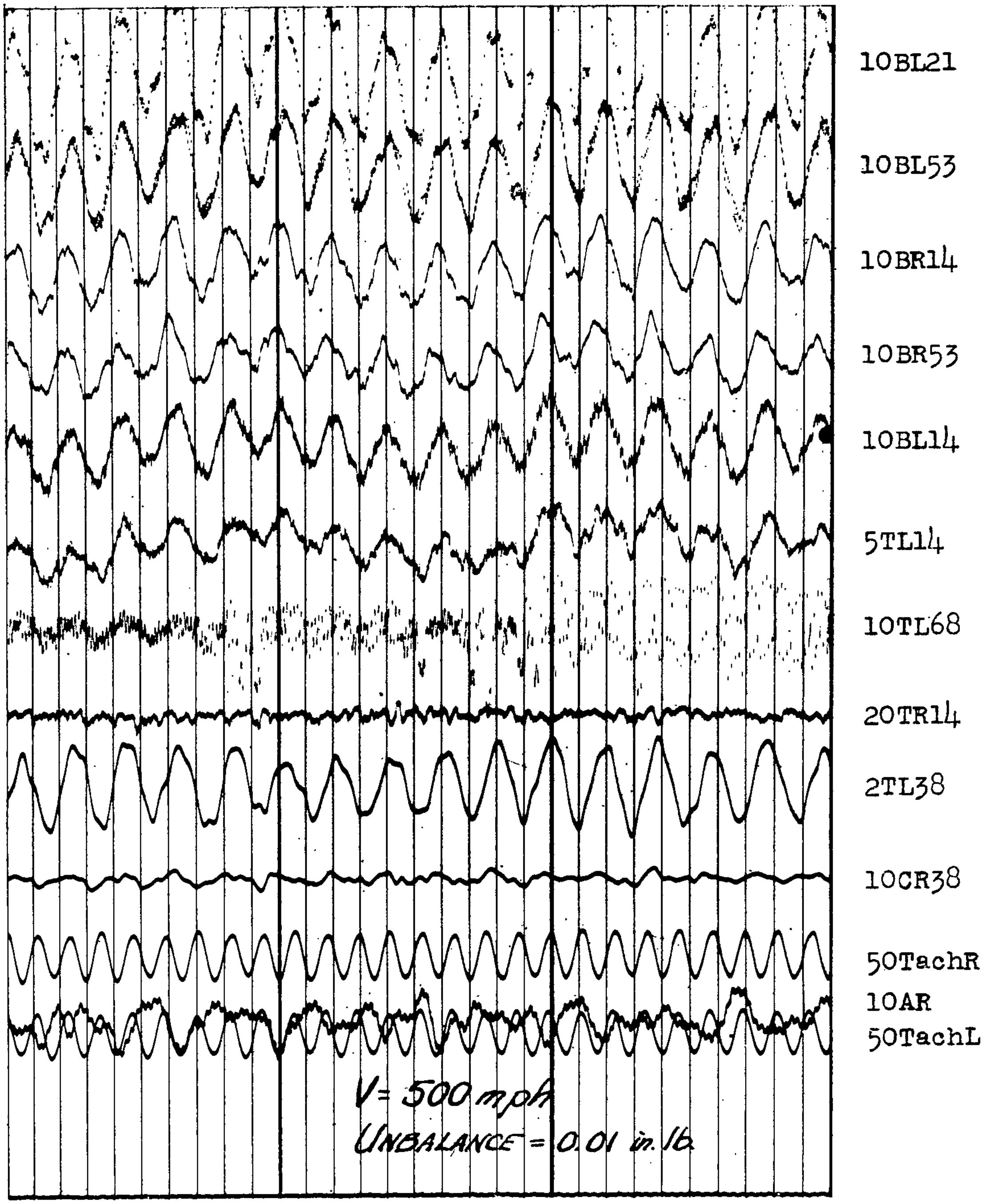

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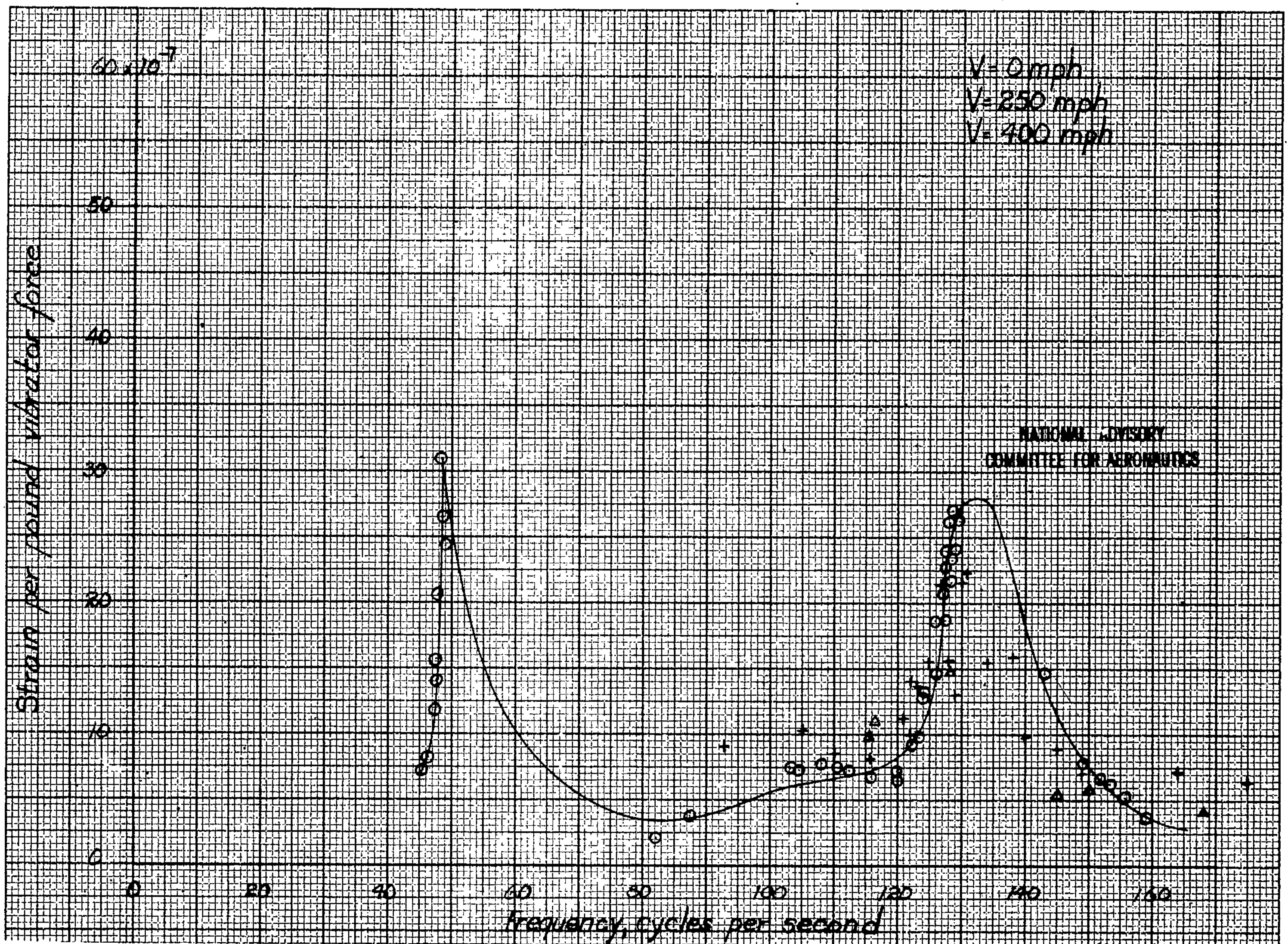
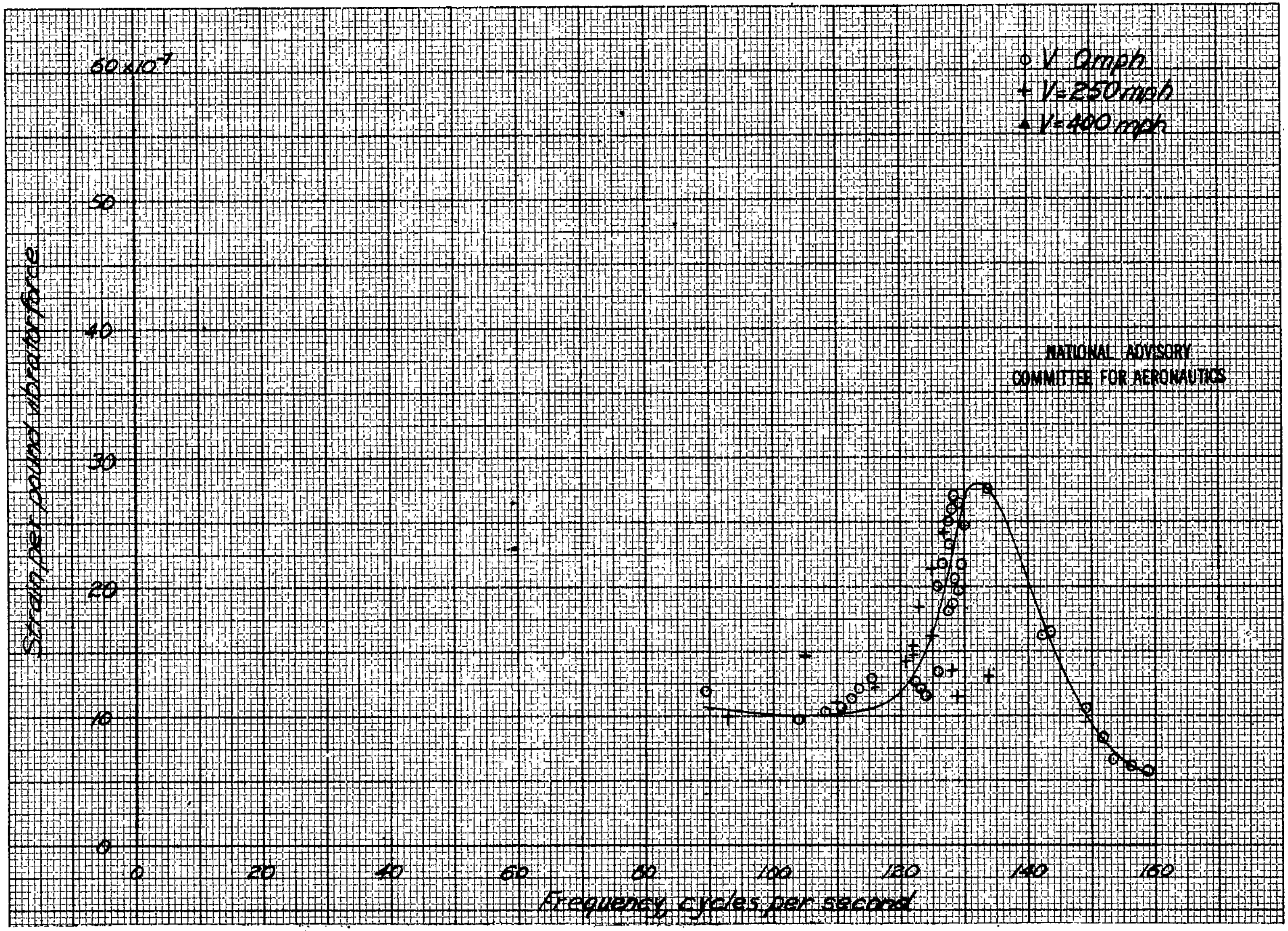
Figure 8.- Oscillograph record taken at about the time of failure of the model. Velocity, 500 miles per hour; (Symbols indicate attenuation and gage designation.)



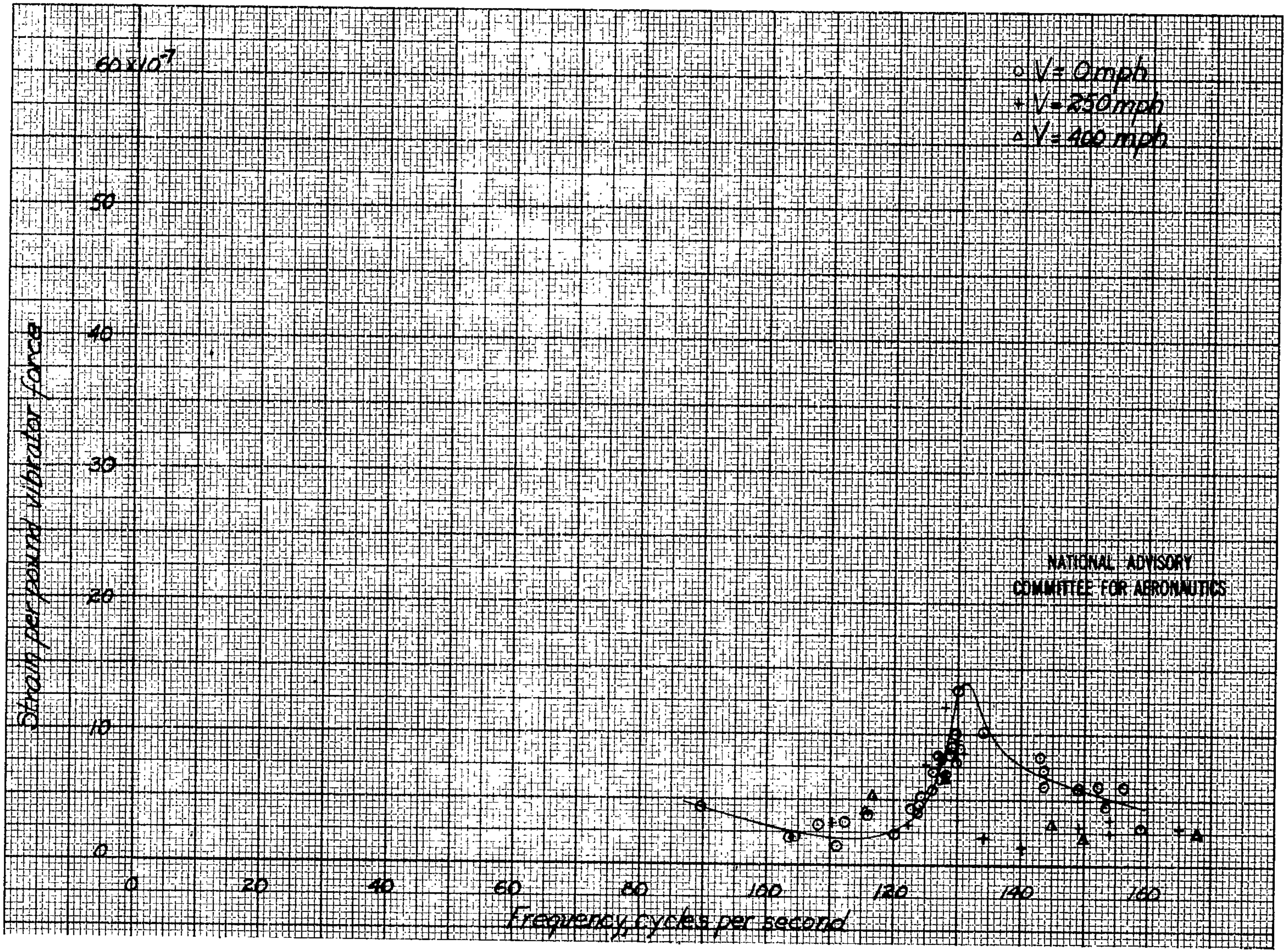
(a) Bending gage in left wing at 53 percent of the semispan.

Figure 9.- Strain per pound of vibrator force as a function of frequency at several airspeeds. Symmetrical excitation.

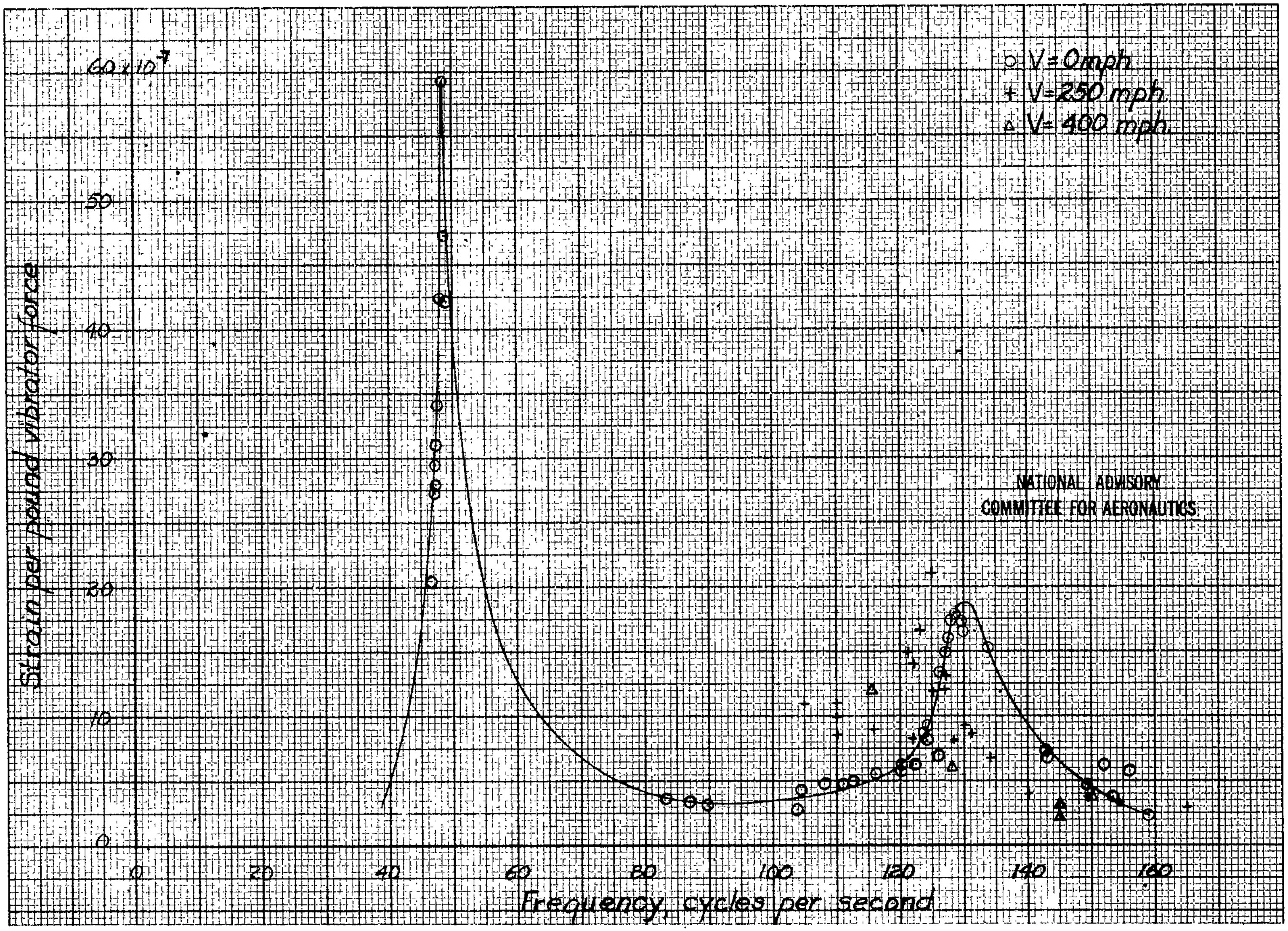


(b) Bending gage in right wing at 53 percent of the semispan.

Figure 9.- Continued.

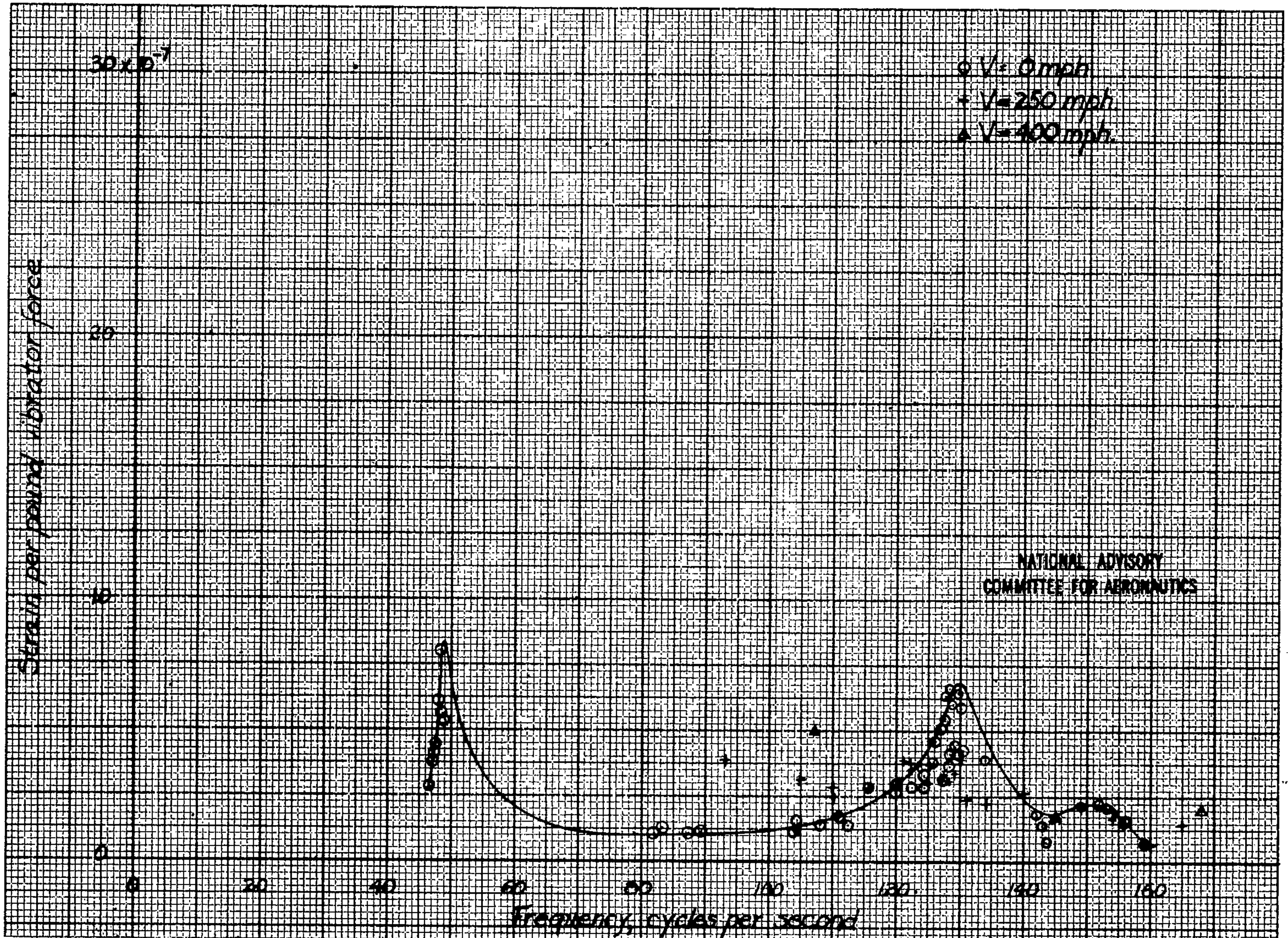


(c) Bending gage in left wing at 21 percent of the semispan.
Figure 9.- Continued.

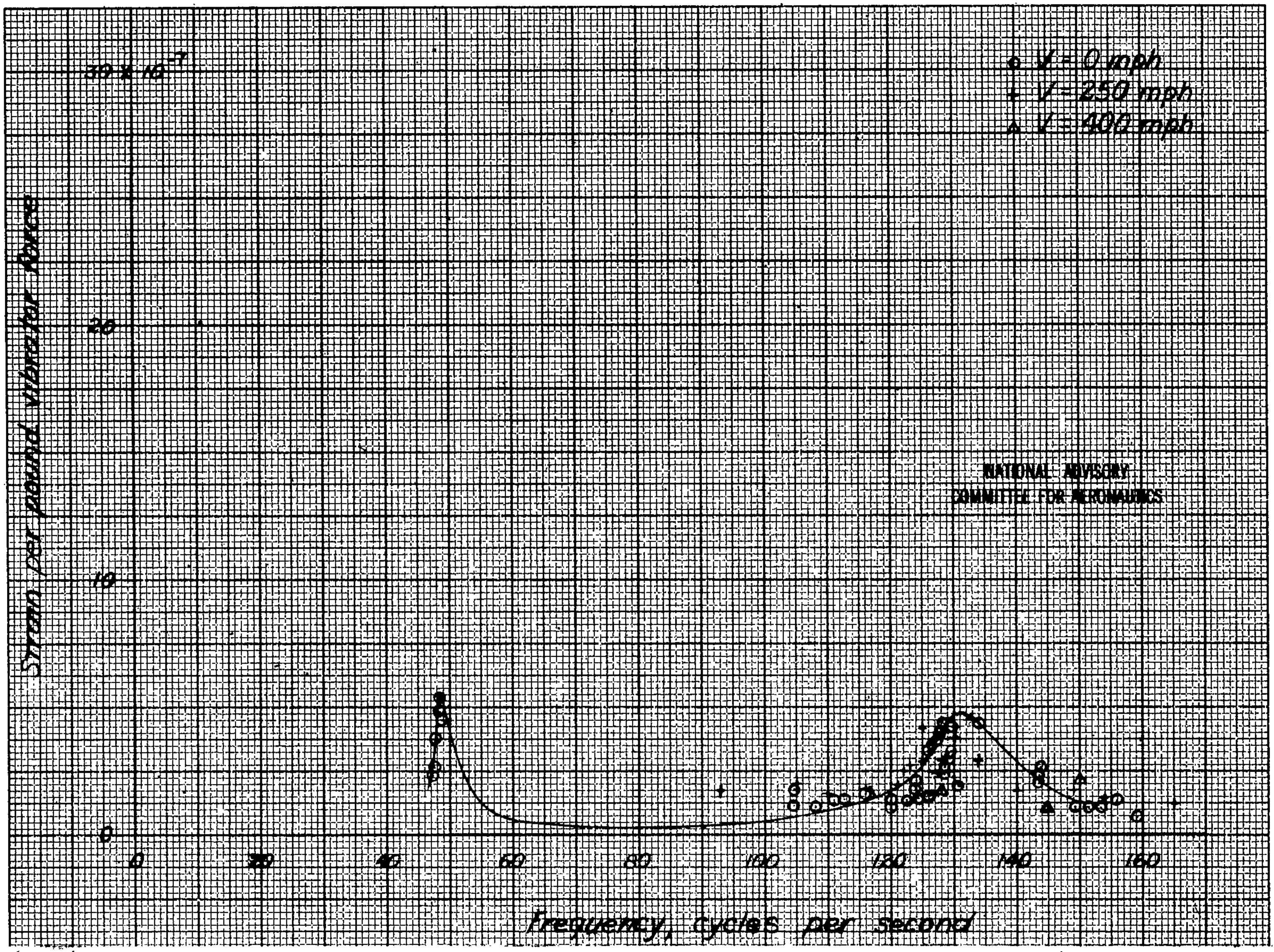


(d) Bending gage in left wing at 14 percent of the semispan.

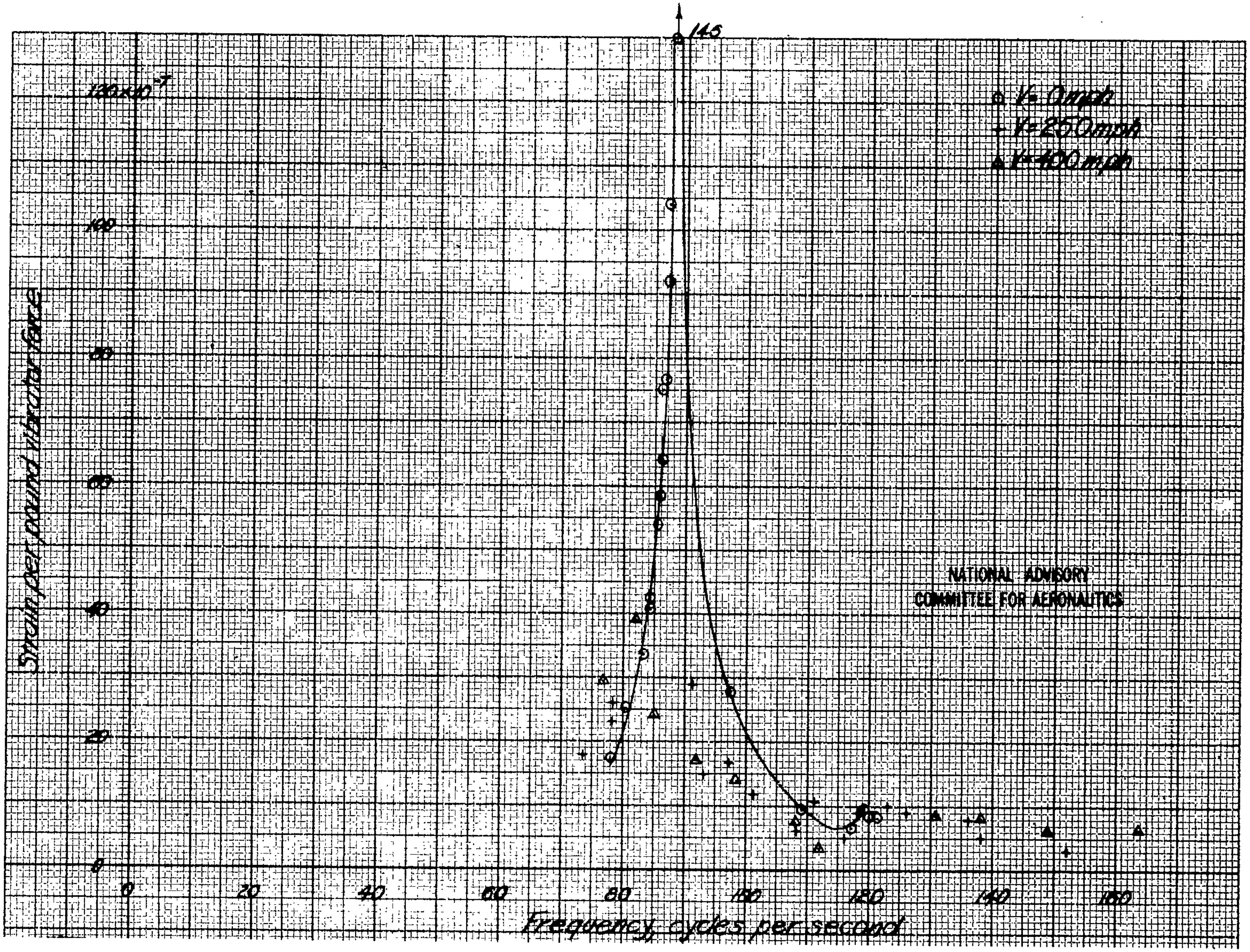
Figure 9.- Continued.



(e) Torsion gage in left wing at 14 percent of the semispan.
Figure 9.- Continued.

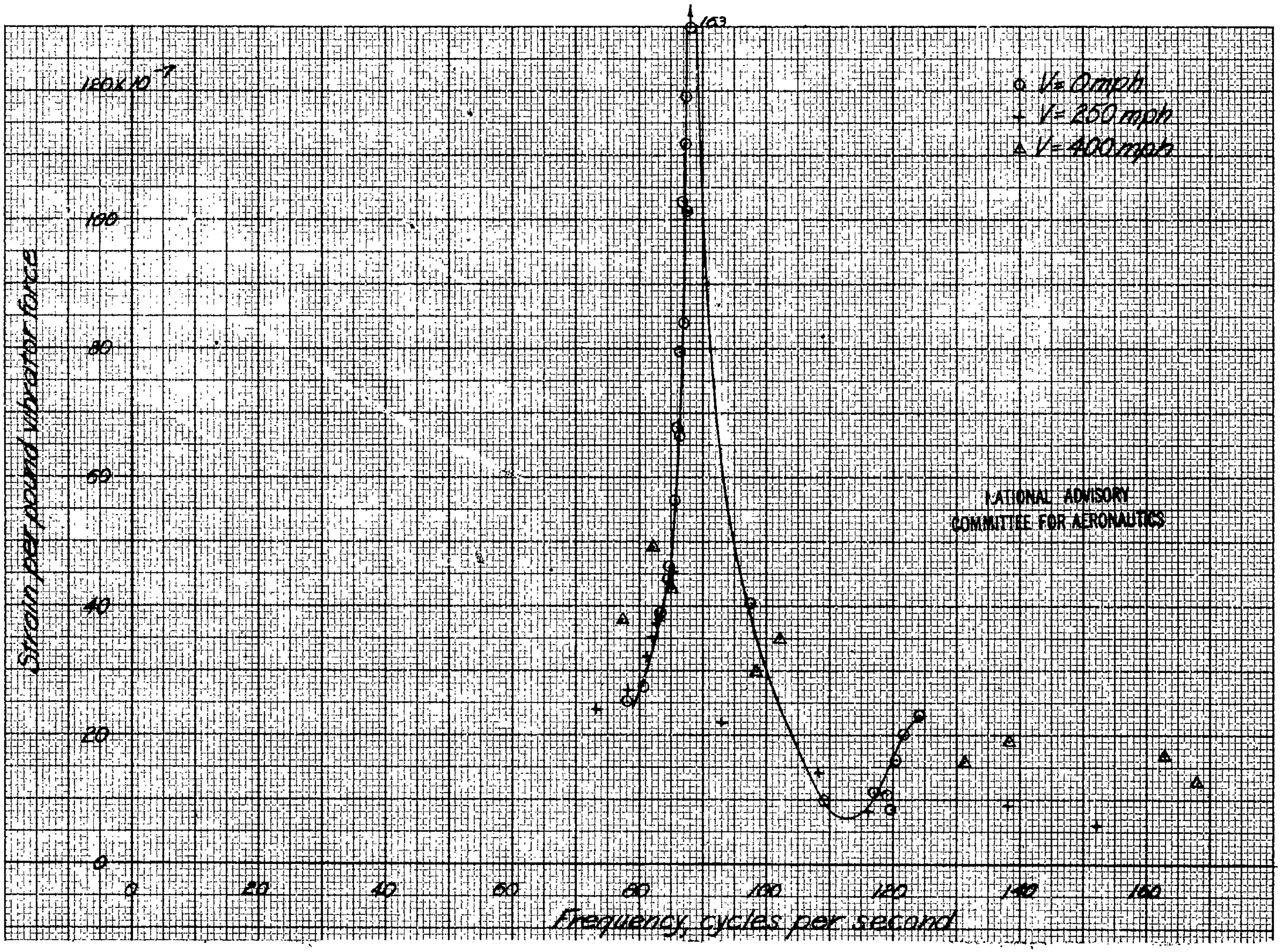


(f) Torsion gage in left wing at 68 percent of the semispan.
Figure 9.- Concluded.

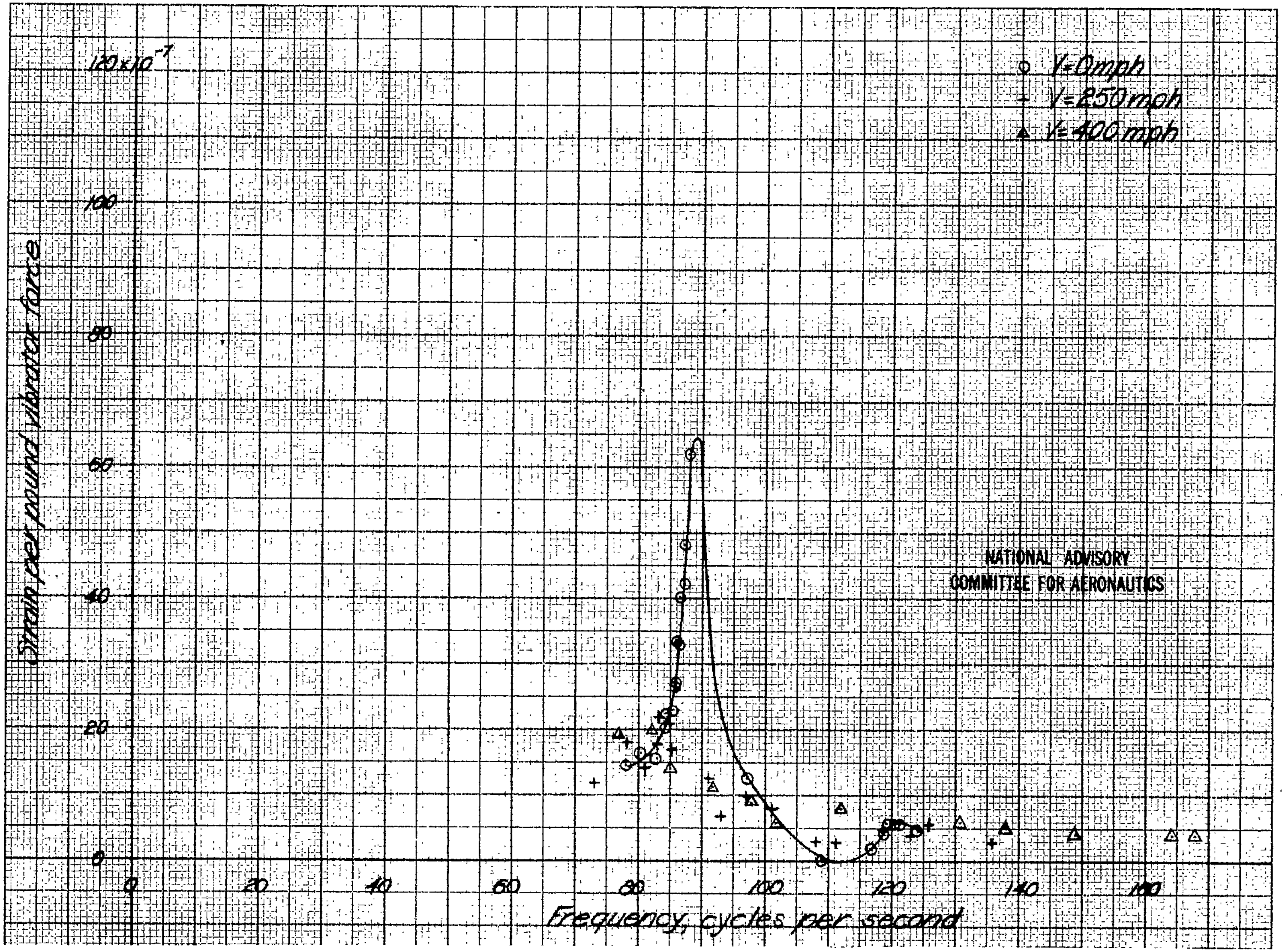


(a) Bending gage in left wing at 53 percent of the semispan.

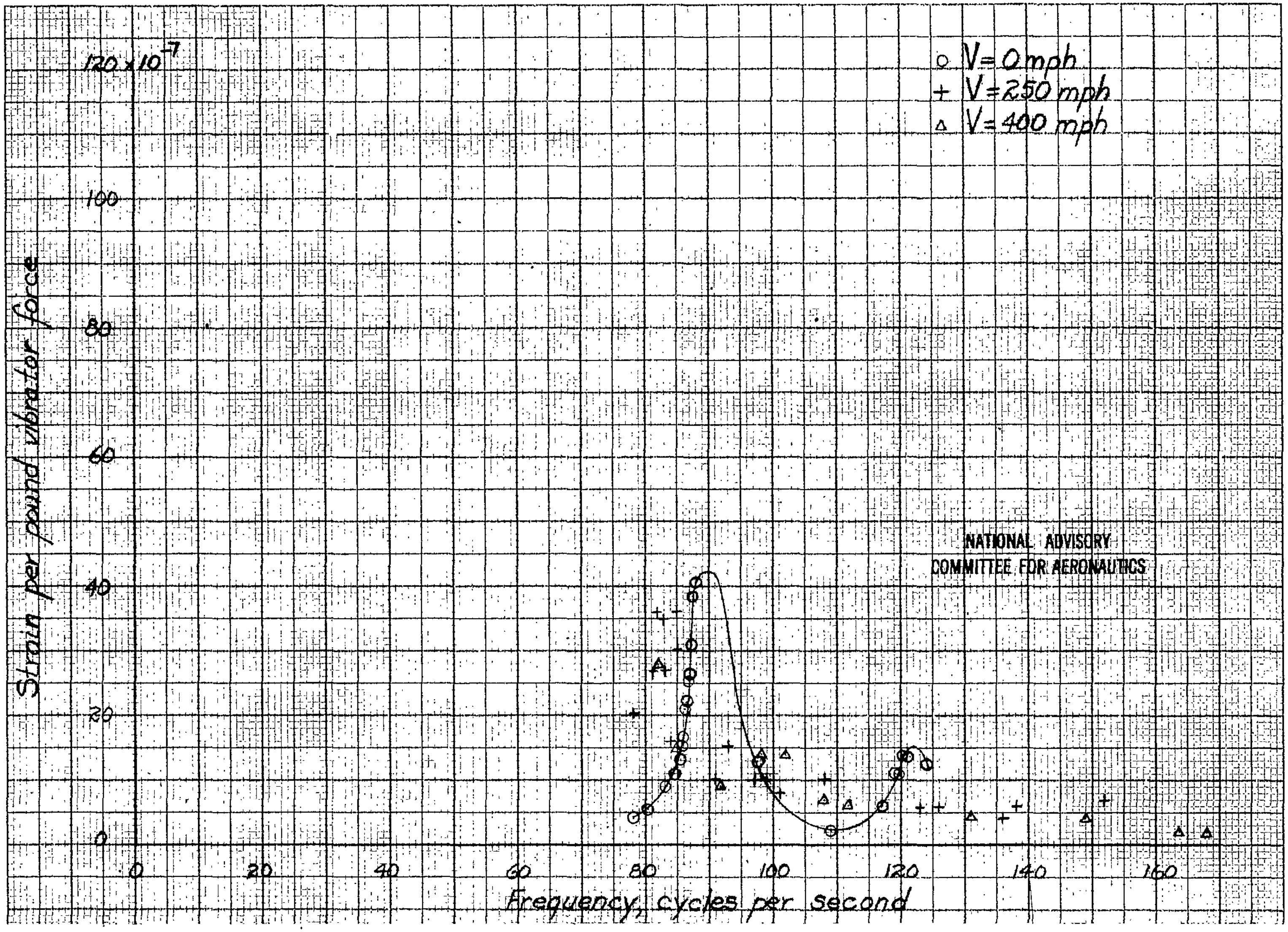
Figure 10.- Strain per pound of vibrator force as a function of frequency at several airspeeds. Unsymmetrical excitation.



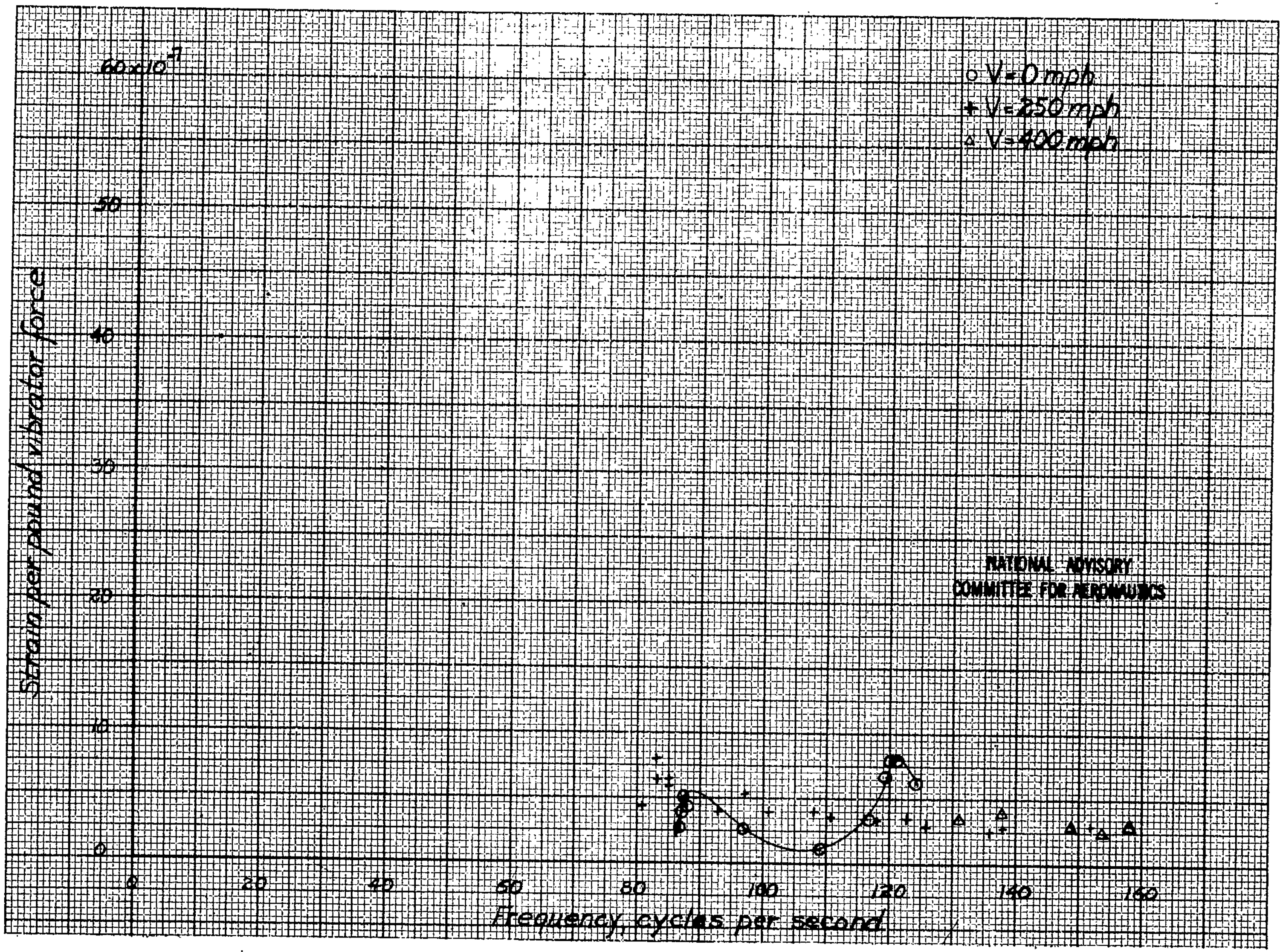
(b) Bending gage in right wing at 53 percent of the semispan.
Figure 10.- Continued.



(c) Bending gage in left wing at 21 percent of the semispan.
Figure 10.- Continued.

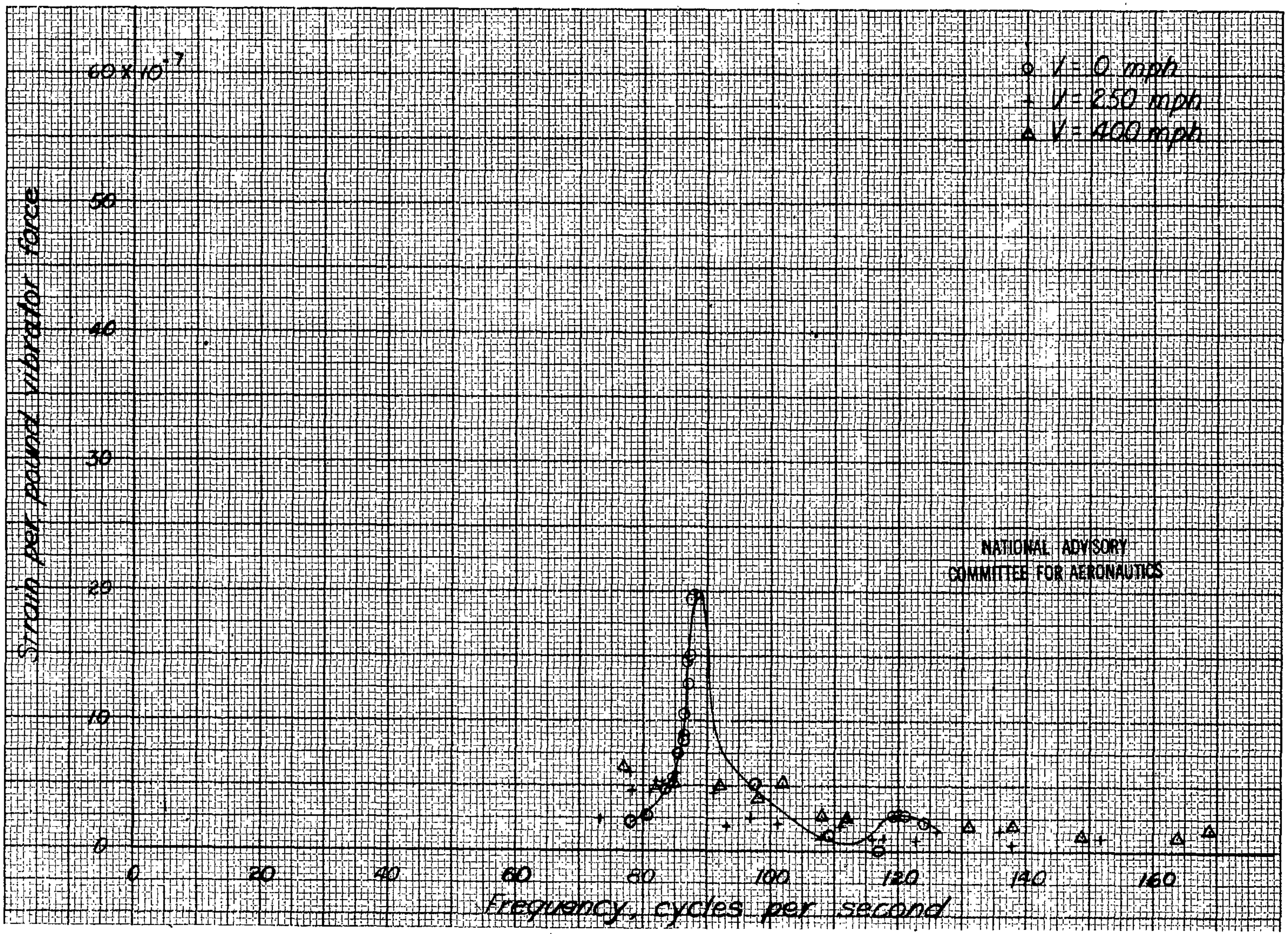


(d) Bending gage in left wing at 14 percent of the semispan.
Figure 10.- Continued.



(e) Torsion gage in left wing at 14 percent of the semispan.

Figure 10.- Continued.



(f) Torsion gage in left wing at 68 percent of the semispan.
Figure 10.- Concluded.

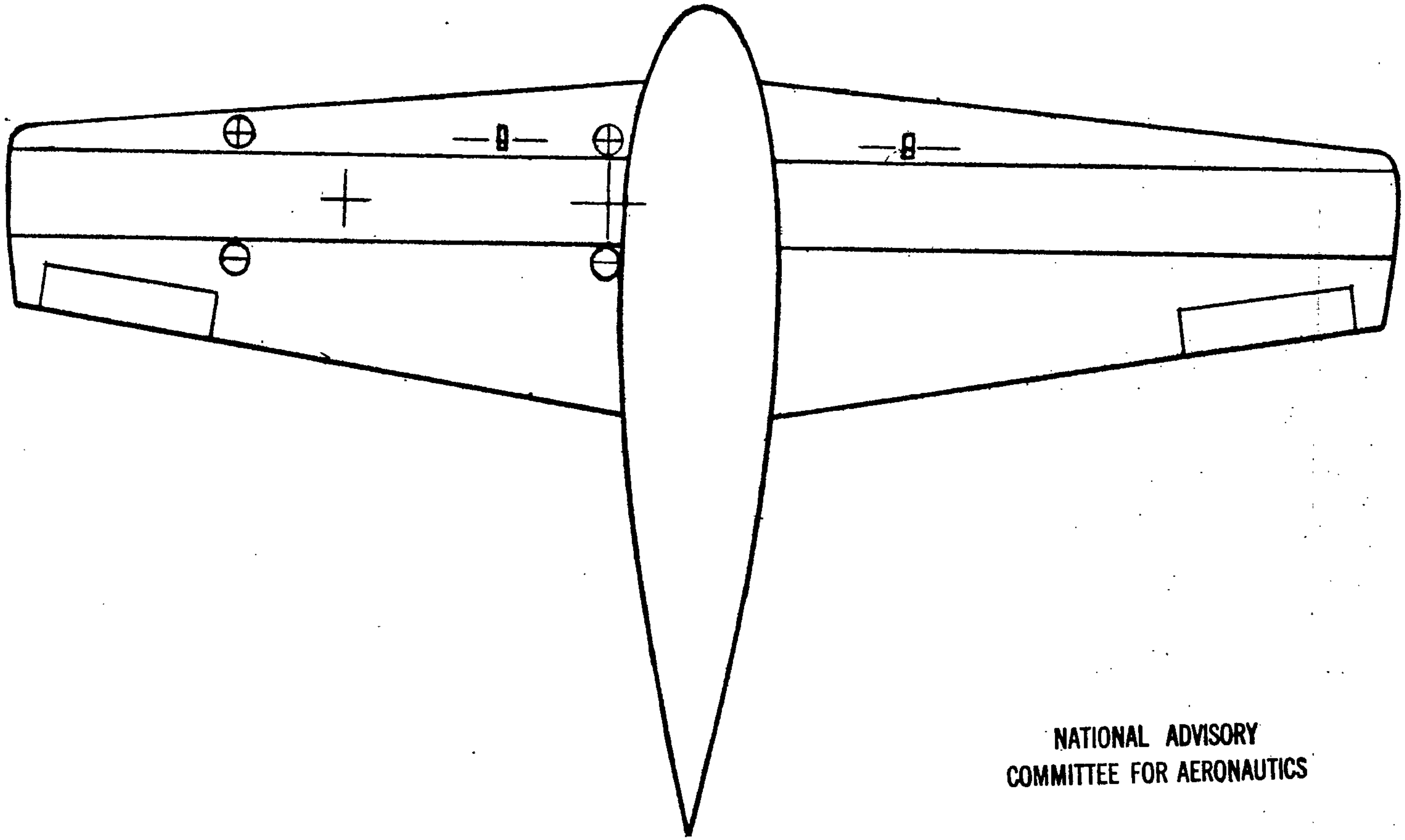


Figure 11.- First symmetrical mode of vibration.
Frequency, 48.5 cycles per second.

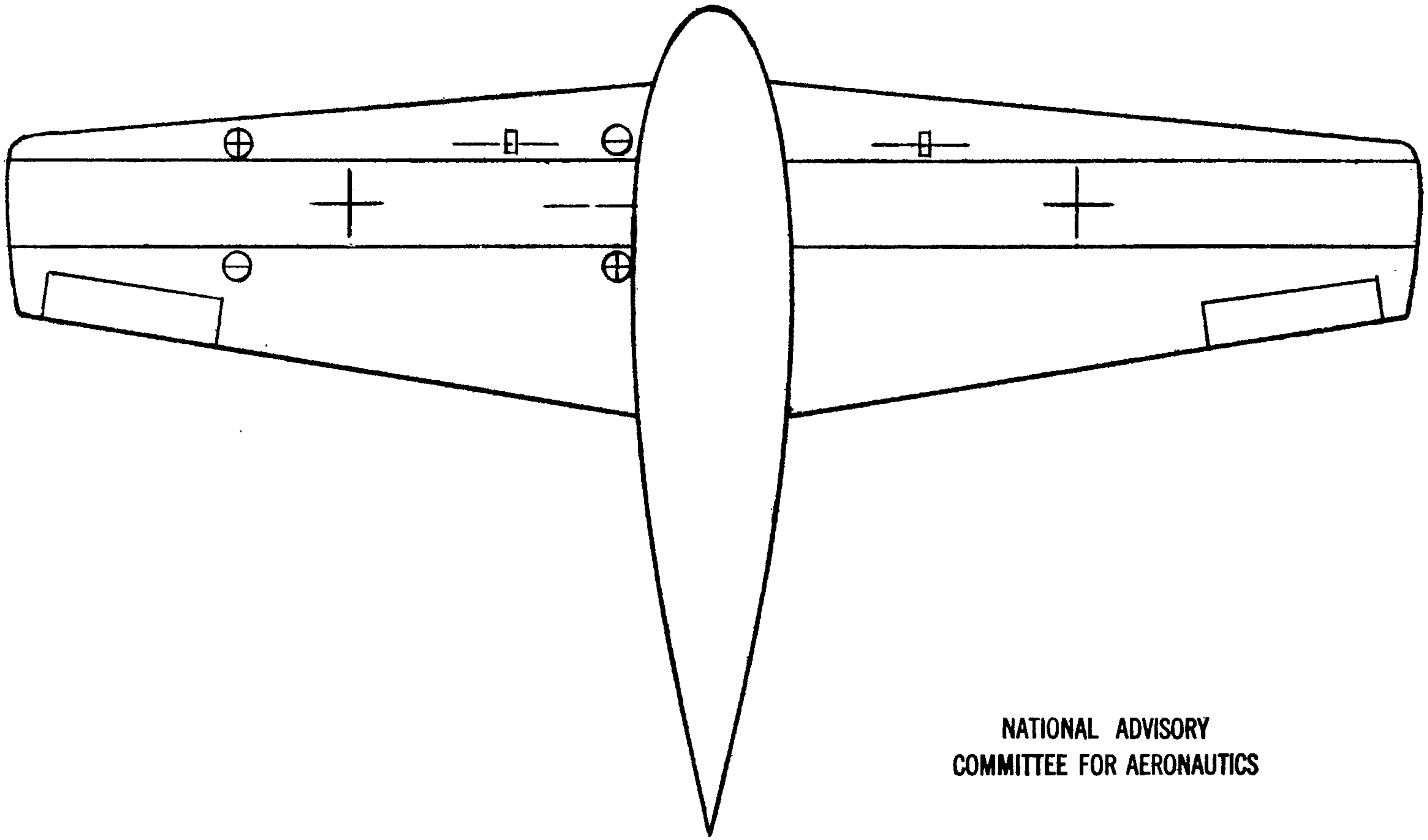


Figure 12.- Second symmetrical mode of vibration. Coupled bending and torsion; frequency, 134 cycles per second.

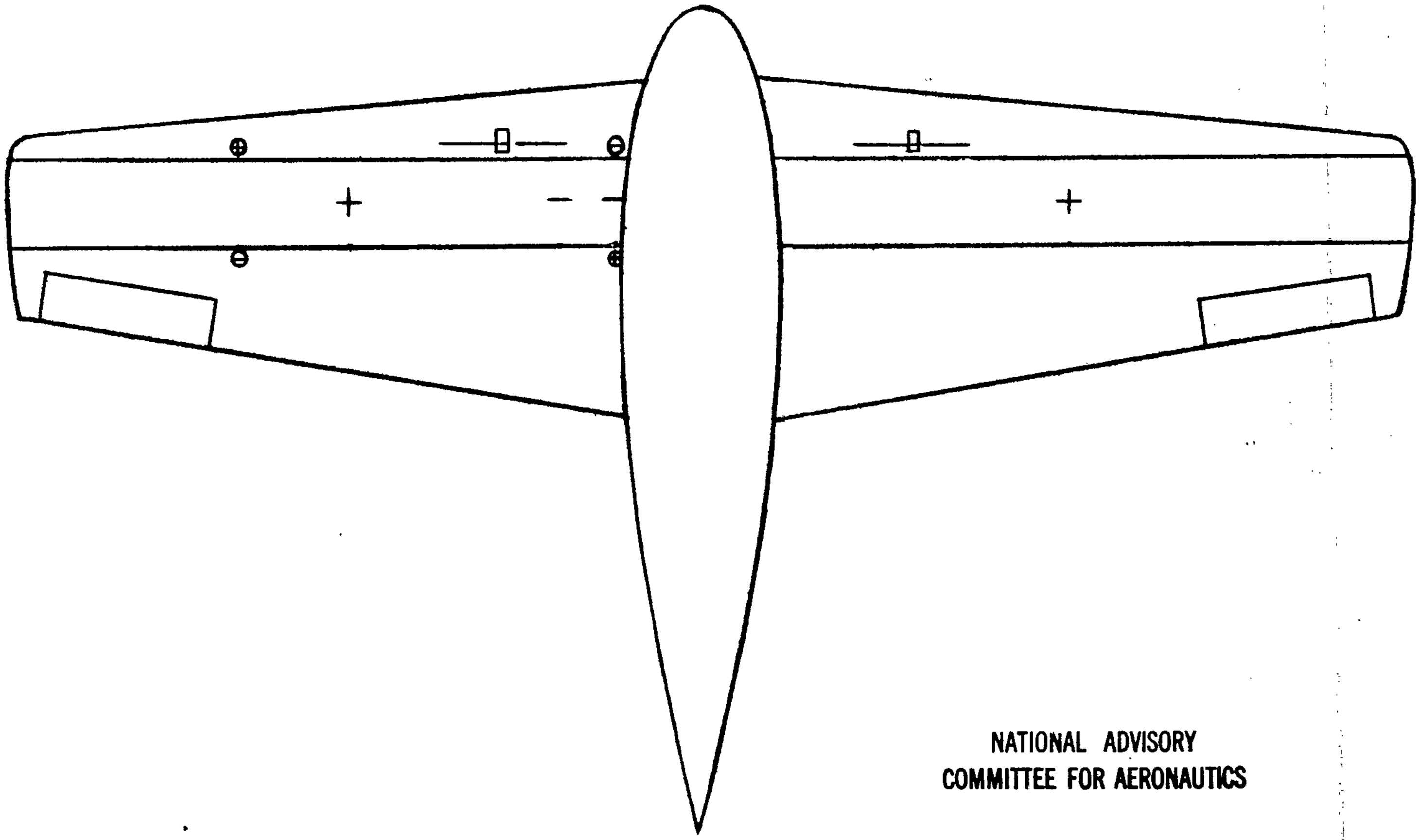


Figure 13.- Symmetrical mode of vibration with no resonance peak.
Frequency, 155 cycles per second.

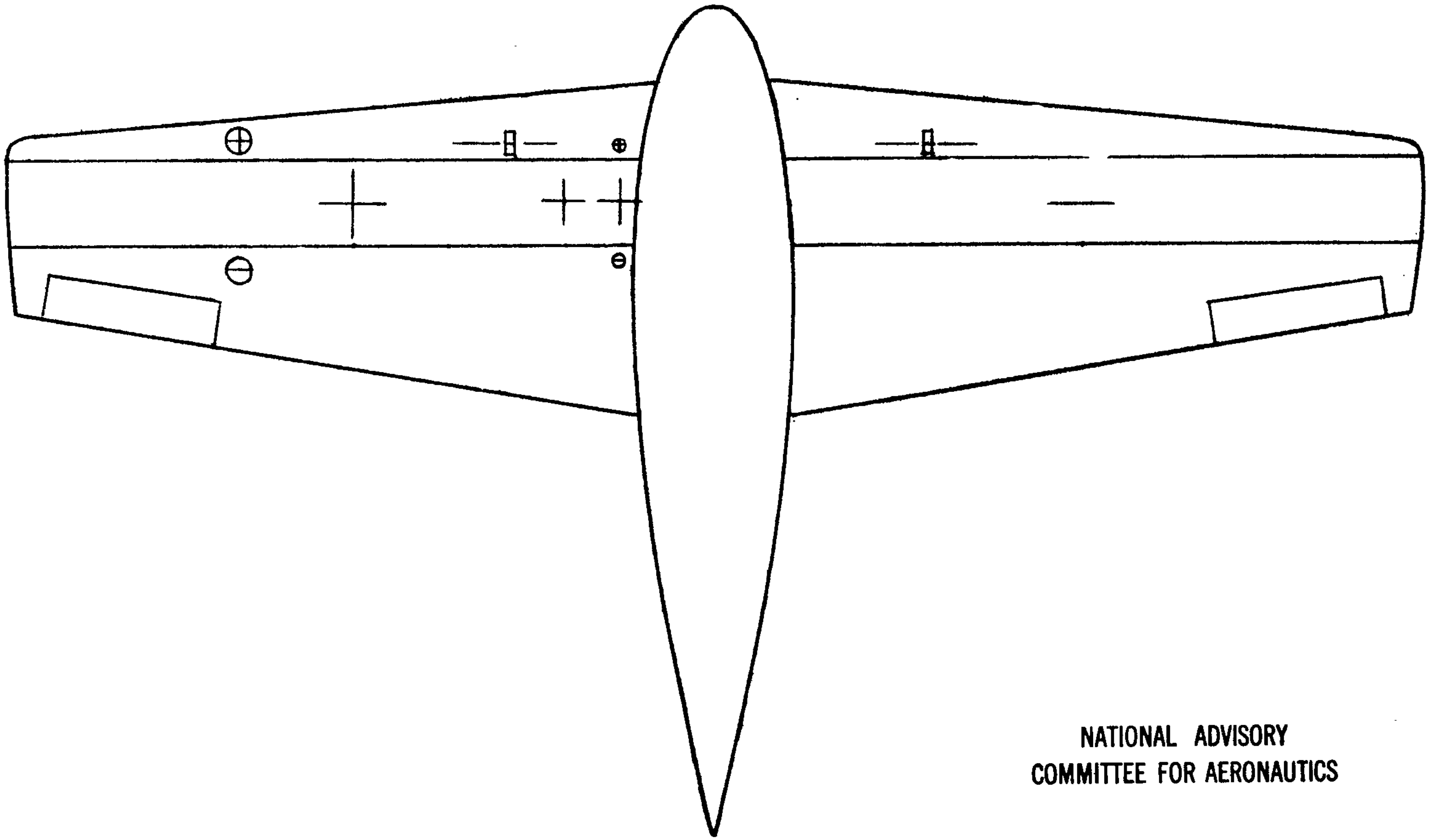


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Figure 14.- First unsymmetrical mode of vibration.
Frequency, 89 cycles per second.

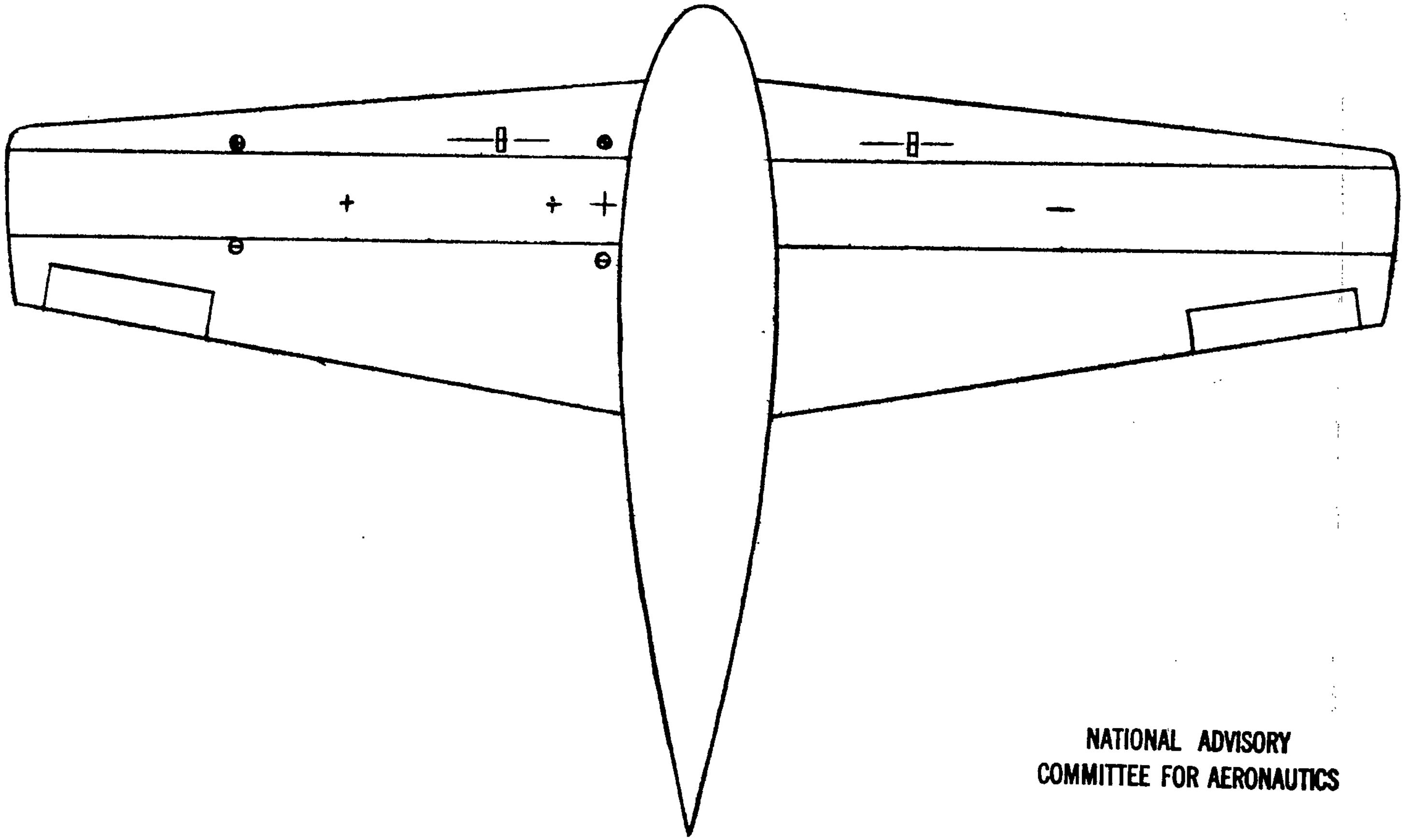

Figure 15.- Second unsymmetrical mode of vibration.
Frequency, 121 cycles per second.

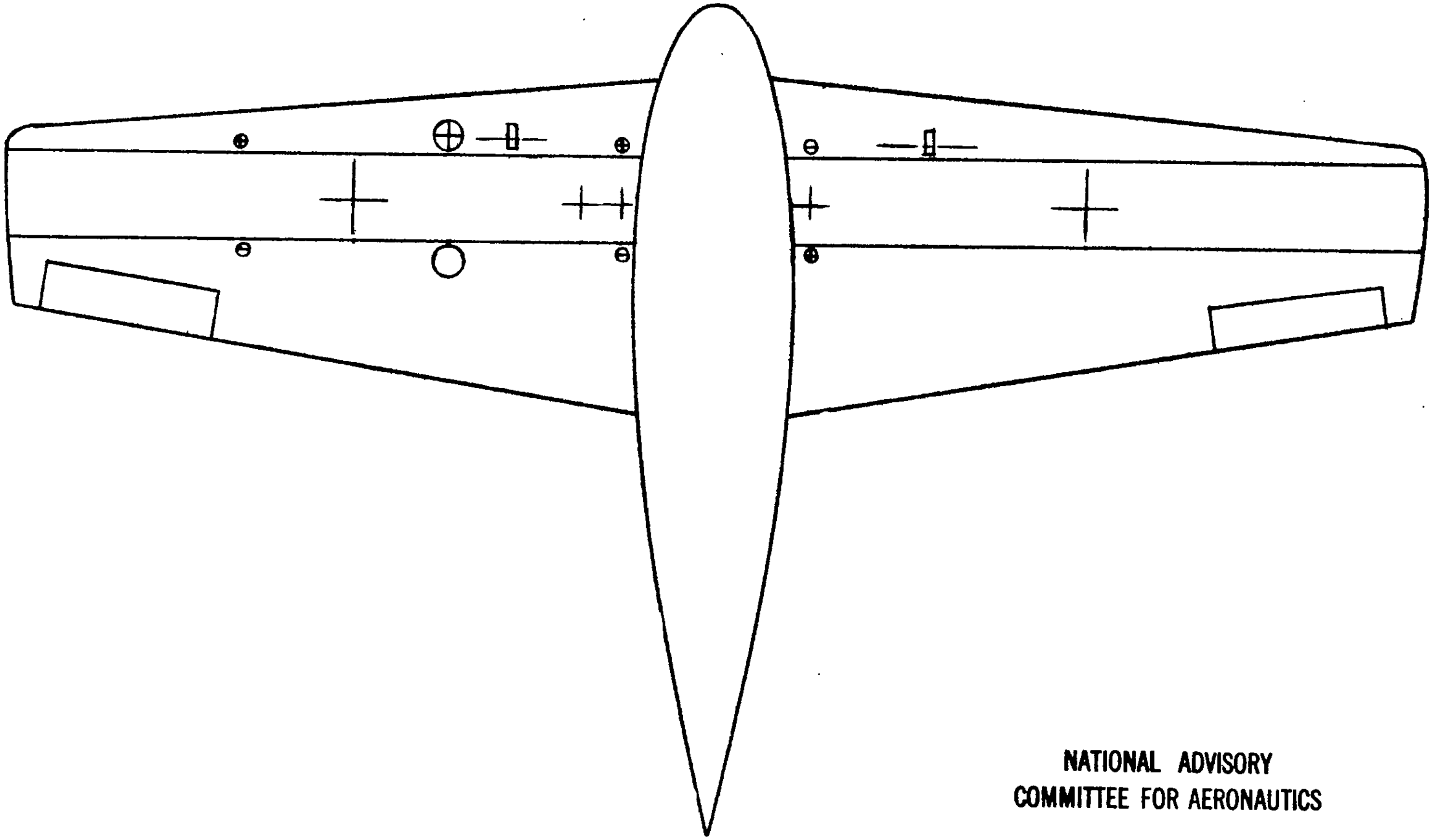

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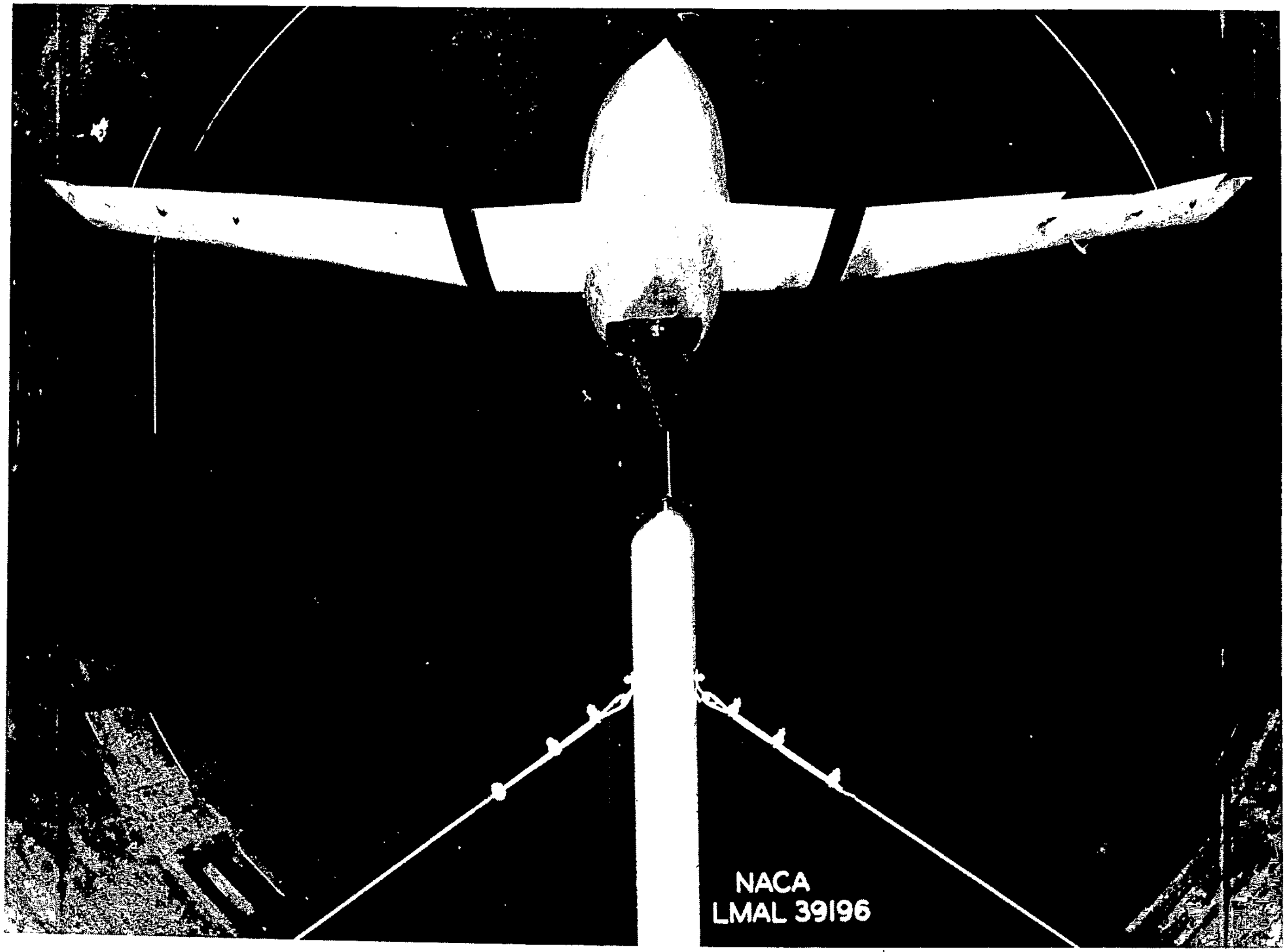
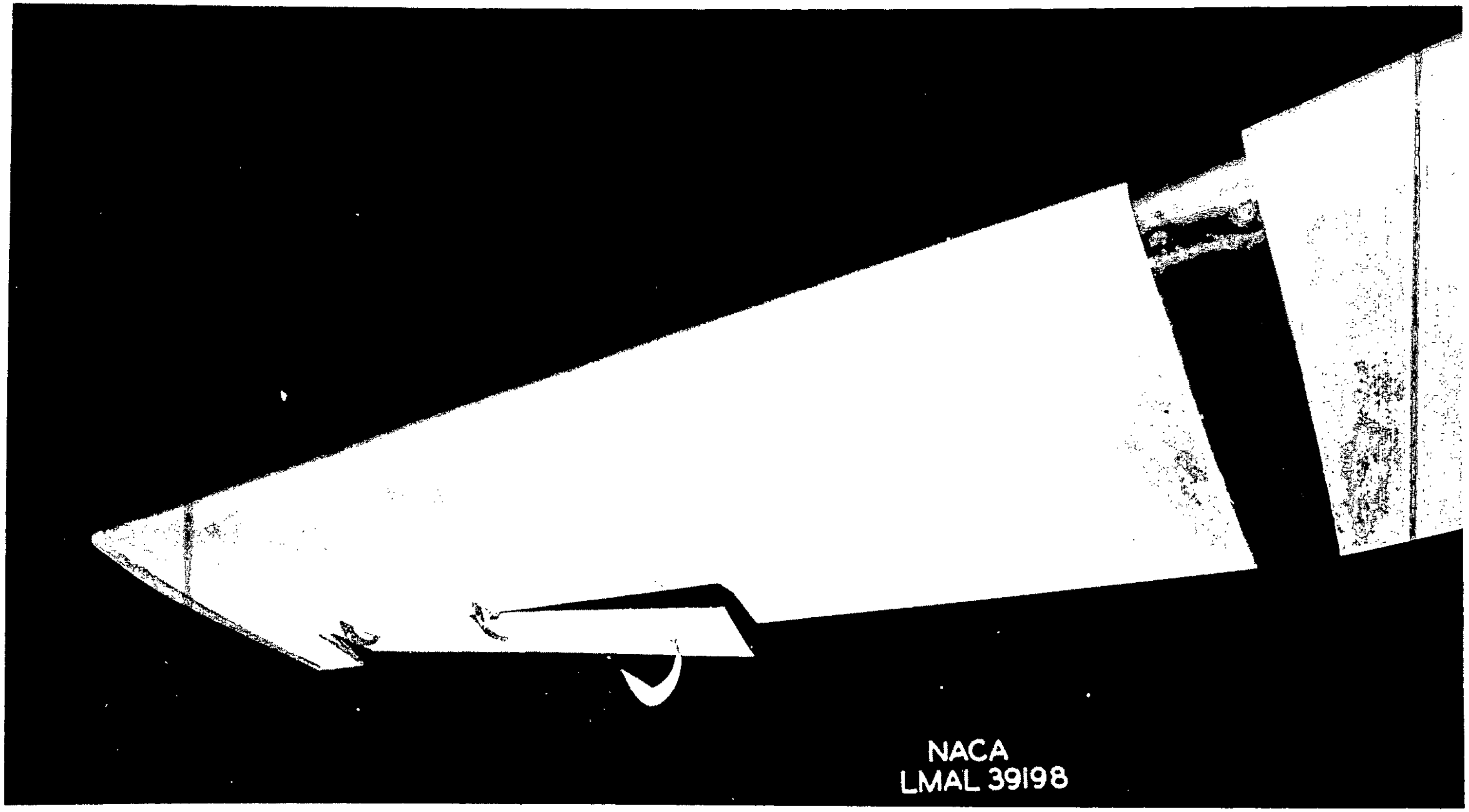
Figure 16.- Mode of vibration for 500 miles per hour at failure of model. Frequency, 50 cycles per second.



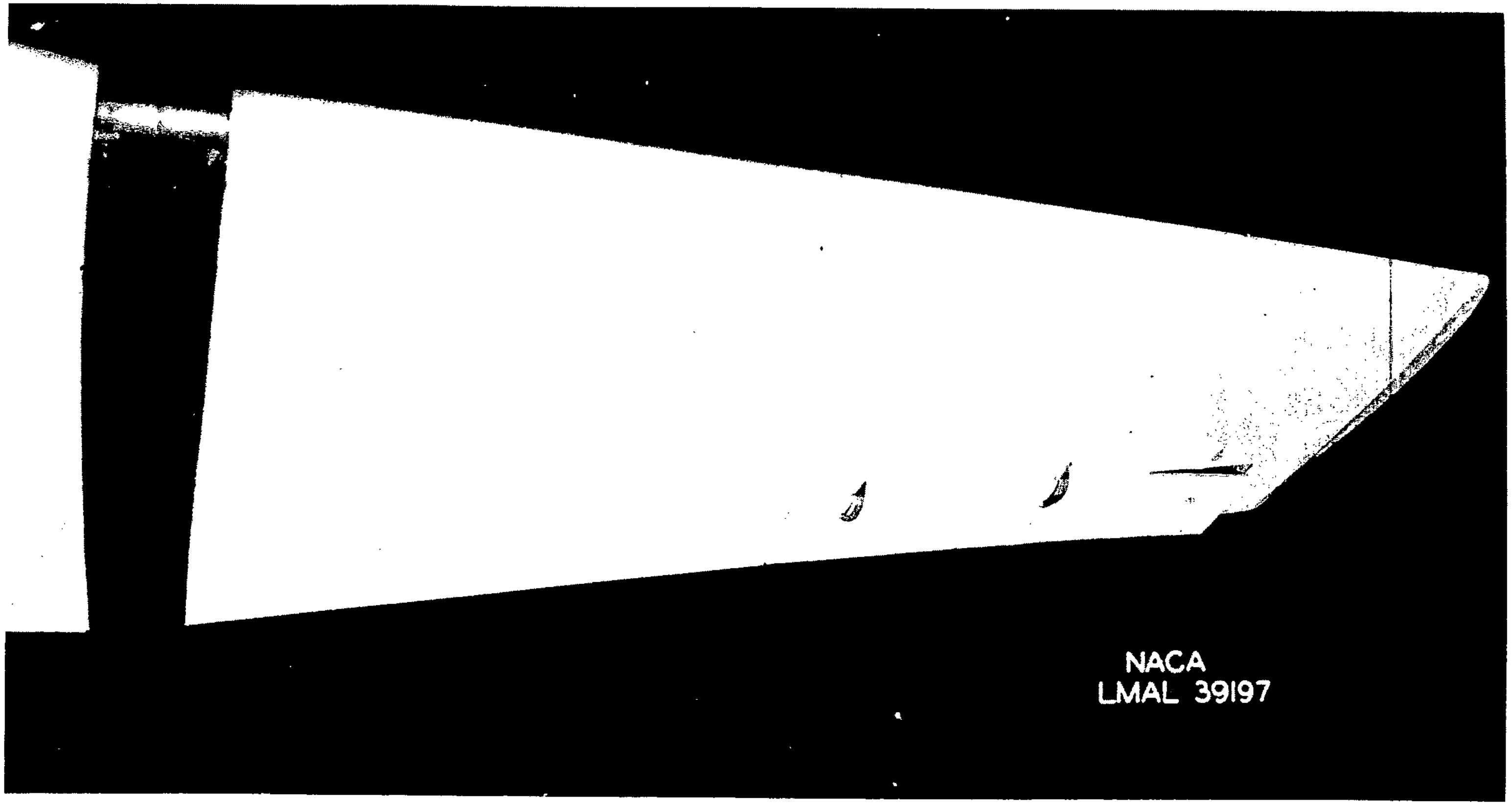
(a) Over-all view.

Figure 17.- Model after failure.



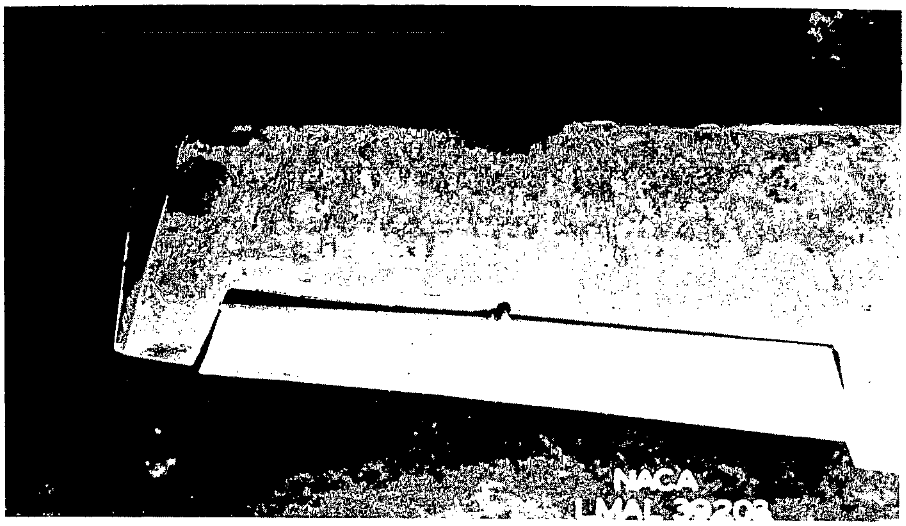
(b) Right wing.

Figure 17.- Model after failure. Continued.



(c) Left wing.

Figure 17.- Model after failure. Continued.



(d) Aileron.

Figure 17.- Model after failure. Concluded.